

C1 hydrogen atoms having a binding energy of about  $E_b = 13.6/n^2$  eV, where n is a fraction whose numerator is 1 and a denominator is an integer greater than 1].

C2 Claim 54, line 1, replace "maintains" with -]- is constructed and arranged to be capable of maintaining -]-.

C3 4 55. (Amended) A cell according to claim 52, [whereby said gaseous hydrogen atoms are formed in the cell by reacting] further comprising a source of hydrogen atoms including molecules containing hydrogen atoms, and a second catalyst for disassociating said molecules to produce hydrogen atoms.

C3 56. (Amended) A cell according to claim 55, wherein said second catalyst [is] comprises at least one element selected from the group consisting of transition elements, [and] inner transition elements, precious metals, refractory metals, lanthanides, actinides, and activated charcoal.

C4 58. (Amended) A cell according to claim 52, wherein said gaseous catalyst is formed from a source of gaseous catalyst which is adapted to sublime, boil, or volatilize when heated.

C5 69. (Amended) A cell according to claim 52, [whereby] wherein said vessel includes temperature controlling structure capable of maintaining [maintains a] an atomic hydrogen partial pressure of less than about 1 torr.

C5 70. (Amended) A cell according to claim 52, wherein said vessel includes temperature controlling structure capable of maintaining [maintains] said catalyst in molten form.

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71<sup>20</sup> (Amended) A cell according to claim 52<sup>1</sup>, wherein said vessel includes temperature controlling structure capable of maintaining the temperature of said vessel [is maintained] at about 50°C above the melting point of said gaseous catalyst.

72<sup>21</sup> (Amended) A cell according to claim 52<sup>1</sup>, wherein said vessel is constructed and arranged to be capable of maintaining the hydrogen partial pressure in said vessel [is maintained] at about 200 millitorr.

73<sup>22</sup> (Amended) A cell according to claim 66<sup>15</sup>, wherein said vessel includes temperature controlling structure capable of maintaining the temperature of said vessel [is maintained] at about 50°C above the [higher] melting point of [compounds of] the compound having the highest melting point of a plurality of compounds which comprise a source [two cations comprising said cation pair] of said gaseous catalyst.

Claim 74, line 1, delete ~~"selectively"~~.

Claim 75, line 1, delete ~~"selectively"~~.

76<sup>25</sup> (Amended) A cell according to claim 52<sup>1</sup>, wherein said vessel includes temperature controlling structure to control a temperature of said vessel [the vapor pressure of said gaseous catalyst varies with temperature].

77<sup>27</sup> (Amended) A cell according to claim 52<sup>1</sup>, further comprising a catalyst reservoir communicating with said reaction vessel, said catalyst reservoir containing said gaseous catalyst or a source [thereof] of gaseous catalyst.

Claim 84, line 1, replace "832" with - - 82 - -.

C<sup>8</sup> 85.<sup>34</sup> (Amended) A cell according to claim 82,<sup>31</sup> wherein said source of hydrogen atoms comprises a tungsten capillary constructed and arranged to be heated [to between 1800 and 2000K] for dissociating molecules containing hydrogen atoms to produce said gaseous hydrogen atoms.

[ Claim 91, line 2, replace "energy" with - - power - -.

C<sup>a</sup> 92.<sup>45</sup> (Amended) A method for extracting energy from hydrogen atoms comprising the steps of:

providing a gaseous catalyst having a net enthalpy of reaction of about 27

\* (p/2) eV, where p is an integer greater than 1;

providing gaseous hydrogen atoms; and

reacting said gaseous catalyst with said gaseous hydrogen atoms, thereby releasing energy from said gaseous hydrogen atoms [producing hydrogen atoms having a binding energy of about  $E_b = 13.6/n^2$  eV, where n is a fraction whose numerator is 1 and a denominator is an integer greater than 1,

said reaction occurring at a pressure less than atmospheric pressure].

[ Claim 94, line 2, replace "catalyst" with - - second catalyst - -.

Claim 107, second line, delete "said".

Please add new claims 108-551 as follows.

C<sup>10</sup> - 108.<sup>41</sup> A cell according to claim 52,<sup>1</sup> wherein said source of gaseous catalyst comprises an ionic compound which is resistant to hydrogen reduction and which is adapted to sublime, boil or become volatile when heated.

42  
109. A cell according to claim 52, wherein said source of gaseous catalyst comprises an ionic compound which is adapted to sublime, boil or become volatile when heated.

43  
110. A cell according to claim 52, wherein said source of gaseous catalyst comprises an ionic compound which is resistant to thermal degradation.

44  
111. A cell according to claim 52, wherein said gaseous catalyst is formed from at least one metal selected from the group consisting of Mo, Ti, and Rb.

45  
112. A cell according to claim 52, wherein said gaseous catalyst is formed from at least one salt selected from the group consisting of  $\text{MoI}_2$ ,  $\text{TiCl}_2$ ,  $\text{TiCl}_4$ ,  $\text{SnCl}_4$ ,  $\text{SiCl}_4$ ,  $\text{PrBr}_3$ ,  $\text{CaBr}_2$ ,  $\text{SrCl}_2$ ,  $\text{CrI}_2$ ,  $\text{TbI}_3$ ,  $\text{SbCl}_3$ ,  $\text{CrF}_3$ ,  $\text{CoCl}_2$ ,  $\text{BiCl}_3$ ,  $\text{NiCl}_2$ ,  $\text{PdF}_2$ ,  $\text{InCl}$ ,  $\text{LaCl}_3$ ,  $\text{DyCl}_3$ ,  $\text{LaI}_3$ ,  $\text{HoI}_3$ ,  $\text{KNO}_3$ ,  $\text{VF}_3$ ,  $\text{PbF}_2$ ,  $\text{VOCl}$ ,  $\text{PbI}_2$ ,  $\text{LuCl}_3$ ,  $\text{PbCl}_2$ ,  $\text{AsI}_3$ ,  $\text{HoI}_3$ ,  $\text{MoCl}_5$ ,  $\text{SnCl}_4$ ,  $\text{SbI}_3$ ,  $\text{CdI}_2$ ,  $\text{AgF}_2$ ,  $\text{AgF}$ ,  $\text{LaI}_3$ ,  $\text{ErI}_3$ ,  $\text{VCl}_4$ ,  $\text{BCl}_3$ ,  $\text{FeCl}_3$ ,  $\text{TiCl}_3$ ,  $\text{CoI}_2$ ,  $\text{CoF}_2$ ,  $\text{TlI}$ ,  $\text{TlF}$ ,  $\text{BiBr}_3$ ,  $\text{ZnBr}_2$ ,  $\text{AsI}_3$ ,  $\text{DyI}_3$ ,  $\text{HoCl}_3$ ,  $\text{MgCl}_2$ ,  $\text{CrCl}_3$ ,  $\text{PrCl}_3$ ,  $\text{SrCl}_2$ ,  $\text{FeCl}_2$ ,  $\text{NiCl}_2$ ,  $\text{CuCl}$ ,  $\text{SrCl}_2$ ,  $\text{MoCl}_2$ ,  $\text{YCl}_3$ ,  $\text{ZrCl}_4$ ,  $\text{CdI}_2$ ,  $\text{BaI}_2$ ,  $\text{HoI}_3$ ,  $\text{PbI}_2$ ,  $\text{PdF}_2$ ,  $\text{LiF}$ ,  $\text{EuCl}_3$ ,  $\text{MgCl}_2$ ,  $\text{ErCl}_3$ ,  $\text{MgCl}_2$ ,  $\text{ErCl}_3$ ,  $\text{MgCl}_2$ ,  $\text{BiCl}_4$ ,  $\text{AlCl}_3$ ,  $\text{CaBr}_2$ ,  $\text{SmBr}_3$ ,  $\text{VaF}_3$ ,  $\text{LaCl}_3$ ,  $\text{GdI}_3$ ,  $\text{CrI}_2$ ,  $\text{MnI}_2$ ,  $\text{YbBr}_3$ ,  $\text{FeBr}_2$ ,  $\text{NiCl}_2$ ,  $\text{AgCl}$ ,  $\text{ZnCl}_2$ ,  $\text{YbCl}_2$ ,  $\text{SeF}_4$ ,  $\text{SnCl}_4$ ,  $\text{SnF}_4$ ,  $\text{SbI}_3$ ,  $\text{BiI}_2$ ,  $\text{EuF}_3$ , and  $\text{PbCl}_2$ .

46  
113. A cell according to claim 52, wherein said catalyst comprises potassium and has a net enthalpy of reaction of 27.28 eV.

47  
114. A cell according to claim 52, wherein said catalyst has a net enthalpy of reaction of about 27.2 eV.

48  
115. A cell according to claim 52, wherein said cell comprises a source of said gaseous catalyst combined with at least one of a hydrocarbon or water disposed such that said gaseous catalyst and said gaseous hydrogen atoms are capable being formed during combustion.

<sup>49</sup>  
~~116.~~ A cell according to claim ~~52~~<sup>1</sup>, further comprising a means for converting a source of catalyst to said gaseous catalyst.

<sup>50</sup>  
~~117.~~ A cell according to claim ~~116~~<sup>49</sup>, wherein said means for converting said source of catalyst to said gaseous catalyst comprises at least one of heat, electron-beam energy, photon energy, acoustic energy, electric field, or magnetic field.

<sup>51</sup>  
~~118.~~ A cell according to claim ~~52~~<sup>1</sup>, further comprising a filament coated with a source of gaseous catalyst.

<sup>52</sup>  
~~119.~~ A cell according to claim ~~52~~<sup>1</sup>, further comprising a source of gaseous hydrogen atoms is selected from the group consisting of hydrogen gas, water, hydrides, metal-hydrogen solutions, and hydrocarbons.

<sup>53</sup>  
~~120.~~ A cell according to claim ~~119~~<sup>52</sup>, further comprising means to disassociate water to form gaseous hydrogen atoms.

<sup>54</sup>  
~~121.~~ A cell according to claim ~~52~~<sup>1</sup>, further comprising a hot filament and a hydrogen containing gas stream.

<sup>55</sup>  
~~122.~~ A cell according to claim ~~52~~<sup>1</sup>, further comprising a hot grid and a hydrogen containing gas stream.

<sup>56</sup>  
~~123.~~ A cell according to claim ~~52~~<sup>1</sup>, further comprising a heated tungsten capillary and a hydrogen containing gas stream.

<sup>57</sup>  
~~124.~~ A cell according to claim ~~52~~<sup>1</sup>, further comprising a hydride maintained under nonequilibrium conditions.

<sup>58</sup>  
~~125~~. A cell according to claim ~~52~~<sup>1</sup>, further comprising an inductively coupled plasma flow tube and a hydrogen gas containing stream.

<sup>59</sup>  
~~126~~. A cell according to claim ~~52~~<sup>1</sup>, further comprising means to reform hydrocarbons to at least one of gaseous molecular and gaseous atomic hydrogen.

<sup>60</sup>  
~~127~~. A cell according to claim ~~55~~<sup>4</sup>, wherein said second catalyst is treated with an aqueous solution of  $K_2CO_3$  and  $H_2O_2$ .

<sup>61</sup>  
~~128~~. A cell according to claim ~~55~~<sup>4</sup>, further comprising a temperature controlling structure capable of maintaining a selected atomic hydrogen partial pressure by controlling the temperature of said second catalyst.

C10  
<sup>62</sup>  
~~129~~. A cell according to claim ~~128~~<sup>61</sup>, wherein said temperature controlling structure is at least one selected from the group consisting of an internal heater, an external heater, the catalysis of hydrogen, and a heat exchanger which removes energy from the cell.

<sup>63</sup>  
~~130~~. A cell according to claim ~~52~~<sup>1</sup>, further comprising a source of UV light for disassociating hydrogen containing molecules to form said gaseous hydrogen atoms.

<sup>64</sup>  
~~131~~. A cell according to claim ~~52~~<sup>1</sup>, further comprising a means for pyrolysis of hydrocarbons or water to form said gaseous hydrogen atoms.

<sup>65</sup>  
~~132~~. A cell according to claim ~~55~~<sup>4</sup>, wherein said second catalyst comprises at least one selected from the group consisting of an element, compound, alloy or mixture of transition elements, inner transition elements, iron, platinum, palladium, zirconium,

vanadium, nickel, titanium, Sc, Cr, Mn, Co, Cu, Zn, Y, Nb, Mo, Tc, Ru, Rh, Ag, Cd, La, Hf, Ta, W, Re, Os, Ir, Au, Hg, Ce, Pr, Nd, Pm, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Vb, Lu, Th, Pa, U, activated charcoal, and intercalated Cs carbon.

66  
133. A cell according to claim ~~55~~<sup>4</sup>, further comprising a heater to heat said second catalyst.

67  
134. A cell according to claim ~~55~~<sup>4</sup>, further comprising a filament or grid constructed and arranged to dissociate hydrogen and to heat said second catalyst.

68  
135. A cell according to claim ~~55~~<sup>4</sup>, further comprising means for controlling the power output of said cell.

69  
136. A cell according to claim ~~135~~<sup>68</sup>, wherein said means for controlling the power output of said cell comprises means for controlling the temperature of said second catalyst.

70  
137. A cell according to claim ~~136~~<sup>69</sup>, wherein said means for controlling the temperature of said second catalyst comprises a filament or grid.

71  
138. A cell according to claim ~~82~~<sup>31</sup>, further comprising a flow control means for controlling the flow of a source of gaseous hydrogen atoms or said gaseous hydrogen atoms from said chamber to said reaction vessel.

72  
139. A cell according to claim ~~52~~<sup>1</sup>, further comprising a flow control means for controlling the flow of hydrogen from said reaction vessel.

73  
140. A cell according to claim ~~138~~<sup>71</sup>, wherein said flow control means comprises a valve.

141. <sup>74</sup> A cell according to claim <sup>1</sup>52, further comprising a vacuum pump constructed and arranged for controlling the flow of hydrogen from said reaction vessel.

142. <sup>75</sup> A cell according to claim <sup>27</sup>78, further comprising a flow control means for controlling the flow of catalyst from said catalyst reservoir to said reaction vessel.

143. <sup>76</sup> A cell according claim <sup>1</sup>52, further comprising means for controlling the flow of said gaseous catalyst from said reaction vessel.

144. <sup>77</sup> A cell according to claim <sup>76</sup>143, wherein said means for controlling the flow of said gaseous catalyst from said reaction vessel comprises a valve.

C10 145. <sup>78</sup> A cell according to claim <sup>1</sup>52, further comprising a vacuum pump constructed and arranged for controlling the flow of said gaseous catalyst from said reaction vessel.

146. <sup>79</sup> A cell according to claim <sup>1</sup>52, further comprising a nonreactive gas.

147. <sup>80</sup> A cell according to claim <sup>1</sup>52, further comprising a means for controlling the amount of a nonreactive gas in said reaction vessel.

148. <sup>81</sup> A cell according to claim <sup>1</sup>52, further comprising flow control means for controlling the flow of a nonreactive gas into said reaction vessel.

149. <sup>82</sup> A cell according to claim <sup>81</sup>148, wherein said means for controlling the amount of nonreactive gas in said vessel comprises a valve constructed and arranged to regulate the flow of said nonreactive gas into said reaction vessel.



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<sup>83</sup>  
~~150.~~ A cell according to claim ~~52~~<sup>1</sup>, further comprising at least one of a valve or pump constructed and arranged for controlling the flow of a nonreactive gas from said reaction vessel.

<sup>84</sup>  
~~151.~~ A cell according to claim ~~52~~<sup>1</sup>, further comprising a pump in communication with said reaction vessel.

<sup>85</sup>  
~~152.~~ A cell according to claim ~~52~~<sup>1</sup>, further comprising structure for controlling the vapor pressure of said catalyst.

<sup>86</sup>  
~~153.~~ A cell according to claim ~~152~~<sup>85</sup>, wherein said structure for controlling the vapor pressure of said catalyst comprises a heater constructed and arranged to control the temperature of said reaction vessel.

<sup>87</sup>  
~~154.~~ A cell according to claim ~~52~~<sup>1</sup>, further comprising structure for maintaining a selected vapor pressure of said gaseous catalyst or source of said gaseous catalyst.

<sup>88</sup>  
~~155.~~ A cell according to claim ~~78~~<sup>27</sup>, further comprising structure for maintaining a selected vapor pressure of said gaseous catalyst or source of gaseous catalyst.

<sup>89</sup>  
~~156.~~ A cell according to claim ~~155~~<sup>88</sup>, wherein said structure for maintaining a selected vapor pressure of said gaseous catalyst or source of gaseous catalyst comprises a valve constructed and arranged for controlling the flow of said source of gaseous catalyst or gaseous catalyst from said catalyst reservoir and a valve constructed and arranged for controlling the flow of said source of gaseous catalyst or gaseous catalyst from said reaction vessel.

<sup>90</sup>  
~~157.~~ A cell according to claim ~~155~~<sup>88</sup>, wherein said structure for maintaining a selected vapor pressure of said source of gaseous catalyst or said gaseous catalyst

comprises a valve constructed and arranged for controlling the flow of said source of gaseous catalyst or gaseous catalyst from said reaction vessel.

91  
158. A cell according to claim 52, further comprising a valve for releasing hydrogen atoms having a binding energy of about  $E_b = 13.6/n^2$  eV, where n is a fraction whose numerator is 1 and denominator is an integer greater than 1 or a compound containing said hydrogen atoms from said reaction vessel.

92  
159. A cell according to claim 52, further comprising means for adsorbing energy released from said hydrogen atom.

93  
160. A cell according to claim 52, wherein said vessel comprises an internal combustion chamber.

94  
161. A cell according to claim 160, wherein said internal combustion chamber is an engine cylinder.

95  
162. A cell according to claim 52, further comprising means for controlling the power output of said cell.

96  
163. A cell according to claim 162, wherein said means for controlling the power output of said cell comprises means for controlling the amount of said gaseous catalyst.

97  
164. A cell according to claim 163, wherein said means for controlling the amount of gaseous catalyst comprises means for controlling the temperature of said vessel and said gaseous catalyst is selected to have a vapor pressure dependent upon the temperature of said reaction vessel.

<sup>98</sup>  
~~165~~ A cell according to claim ~~162~~<sup>95</sup>, wherein said means for controlling the power output of said cell comprises means for controlling the flow of a source of gaseous catalyst or gaseous catalyst from said reaction vessel.

<sup>99</sup>  
~~166~~ A cell according to claim ~~162~~<sup>95</sup>, wherein said means for controlling the power output of said cell comprises means for controlling the temperature of a source of catalyst.

<sup>100</sup>  
~~167~~ A cell according to claim ~~162~~<sup>95</sup>, wherein said means for controlling the power output of said cell comprises means for controlling the amount of said gaseous hydrogen atoms or a source of gaseous hydrogen atoms in said vessel.

<sup>101</sup>  
~~168~~ A cell according to claim ~~162~~<sup>95</sup>, wherein said means for controlling the power output of said cell comprises means for controlling the flow of gaseous hydrogen atoms or source of said hydrogen atoms into said reaction vessel.

<sup>102</sup>  
~~169~~ A cell according to claim ~~162~~<sup>95</sup>, wherein said means for controlling the power output of said cell comprises means for controlling the flow of gaseous hydrogen atoms or source of said hydrogen atoms from said reaction vessel.

<sup>103</sup>  
~~170~~ A cell according to claim ~~162~~<sup>95</sup>, wherein said means for controlling the power output of said cell comprises controlling the amount of said nonreactive gas present in said reaction vessel.

<sup>104</sup>  
~~171~~ A cell according to claim ~~170~~<sup>103</sup>, wherein said means for controlling the amount of nonreactive gas comprises means for controlling the flow of said nonreactive gas into said reaction vessel.

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<sup>105</sup>172. <sup>103</sup>A cell according to claim ~~170~~<sup>95</sup>, wherein said means for controlling the amount of nonreactive gas comprises means for controlling the flow of said nonreactive gas from said reaction vessel.

<sup>106</sup>173. <sup>95</sup>A cell according to claim ~~162~~<sup>95</sup>, wherein said means for controlling the power output of said cell comprises means for controlling the flow of a hydrogen containing gas over at least one of a hot filament, a tungsten capillary heated by electron bombardment, or an inductively coupled plasma flow.

<sup>107</sup>174. <sup>95</sup>A cell according to claim ~~162~~<sup>95</sup>, wherein said means for controlling the power output of said cell comprises means for controlling the power dissipated in an inductively coupled plasma flow tube.

<sup>108</sup>175. <sup>95</sup>A cell according to claim ~~162~~<sup>95</sup>, wherein said means for controlling the power output of said cell comprises means for controlling the power dissipated in a hot filament, grid, or tungsten capillary heated by electron bombardment.

<sup>109</sup>176. <sup>95</sup>A cell according to claim ~~162~~<sup>95</sup>, wherein said means for controlling the power output of said cell comprises means for controlling the temperature of a hot filament, grid or tungsten capillary heated by electron bombardment over which a hydrogen containing gas flows.

<sup>110</sup>177. <sup>95</sup>A cell according to claim ~~162~~<sup>95</sup>, wherein said means for controlling the power output of said cell comprises means for controlling the temperature of a hydride maintained under nonequilibrium conditions.

<sup>111</sup>178. <sup>27</sup>A cell according to claim ~~78~~<sup>27</sup>, further comprising means for controlling the power output of said cell.

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<sup>112</sup>179. A cell according to claim <sup>111</sup>178, wherein said means for controlling the power output of said cell comprises means for controlling the temperature of said catalyst reservoir and said gaseous catalyst is selected to have a vapor pressure dependent upon the temperature of said catalyst reservoir.

<sup>113</sup>180. A cell according to claim <sup>111</sup>178, wherein said means for controlling the power output of said cell comprises means for controlling the flow of said source of gaseous catalyst or gaseous catalyst from said catalyst reservoir into said reaction vessel.

<sup>114</sup>181. A cell according to claim <sup>1</sup>52, further comprising a boat contained within said reaction chamber, said boat containing a source of gaseous catalyst or said gaseous catalyst.

<sup>115</sup>182. A cell according to claim <sup>114</sup>181, further comprising a means for controlling the power of said cell.

<sup>116</sup>183. A cell according to claim <sup>114</sup>181, wherein said means for controlling the power output of said cell comprises means for controlling the temperature of said boat and said gaseous catalyst is selected to have a vapor pressure dependent upon the temperature of said boat.

<sup>117</sup>184. A cell according to claim <sup>27</sup>78, further comprising means for measuring the temperature of said catalyst reservoir.

<sup>118</sup>185. A cell according to claim <sup>114</sup>181, further comprising means for measuring the temperature of said boat.

<sup>119</sup>  
~~186.~~ A cell according to claim ~~78~~<sup>27</sup>, further comprising a means for measuring the temperature of said source of said gaseous catalyst contained in said catalyst reservoir.

<sup>120</sup>  
~~187.~~ A cell according to claim ~~181~~<sup>114</sup>, further comprising a means for measuring the temperature of said source of said gaseous catalyst contained in said boat.

<sup>121</sup>  
~~188.~~ A cell according to claim ~~52~~<sup>1</sup>, further comprising means for measuring the temperature of said reaction vessel.

<sup>122</sup>  
~~189.~~ A cell according to claim ~~52~~<sup>1</sup>, further comprising means for measuring the temperature of a source of said gaseous hydrogen atoms.

<sup>123</sup>  
~~190.~~ A cell according to claim ~~55~~<sup>4</sup>, further comprising means for measuring the temperature said second catalyst.

<sup>124</sup>  
~~191.~~ A cell according to claim ~~52~~<sup>1</sup>, further comprising means to measure the cell temperature.

<sup>125</sup>  
~~192.~~ A cell according to claim ~~191~~<sup>124</sup>, further comprising temperature controlling structure constructed and arranged to maintain a temperature in said reaction vessel greater than a temperature in said catalyst reservoir.

<sup>126</sup>  
~~193.~~ A cell according to claim ~~181~~<sup>114</sup>, further comprising temperature controlling structure constructed and arranged to maintain a temperature in said reaction vessel greater than a temperature in said boat.

<sup>127</sup>  
~~194.~~ A cell according to claim ~~52~~<sup>1</sup>, further comprising temperature controlling structure for maintaining a selected temperature of said reaction vessel.

128  
195. A cell according to claim 52, further comprising a nebulizer or atomizer.

129  
196. A cell according to claim 52, further comprising means to measure the pressure in said reaction vessel.

130  
197. A cell according to claim 52, further comprising means to measure the hydrogen pressure in said reaction vessel.

131  
198. A cell according to claim 52, further comprising means to measure the gaseous catalyst pressure in said reaction vessel.

132  
199. A cell according to claim 52, wherein said vessel is capable of containing a pressure within the range of  $10^{-3}$  atmospheres to 100 atmospheres.

133  
200. A cell according to claim 52, further comprising a vacuum pump in communication with said vessel and said vessel being constructed and arranged to contain pressures less than atmospheric.

134  
201. A cell according to claim 78, further comprising a temperature controlling structure capable of maintaining a temperature in the said reaction vessel that is greater than a temperature of said catalyst reservoir.

135  
202. A cell according to claim 78, further comprising temperature controlling structure capable of maintaining said source of gaseous catalyst in a molten form.

136  
203. A cell according to claim 114, further comprising temperature controlling structure capable of maintaining said source of gaseous catalyst in a molten form.

<sup>137</sup> 204. A cell according to claim <sup>27</sup> 78, further comprising temperature controlling structure capable of maintaining the temperature of said catalyst reservoir at about 50°C above the melting point of said gaseous catalyst.

<sup>138</sup> 205. A cell according to claim <sup>1</sup> 52, further comprising temperature controlling structure capable of maintaining the temperature of said reaction vessel at about 50°C above the melting point of a source of gaseous catalyst.

<sup>139</sup> 206. A cell according to claim <sup>114</sup> 181, further comprising temperature controlling structure capable of maintaining the temperature of said boat at about 50°C above the melting point of said gaseous catalyst.

<sup>140</sup> 207. A cell according to claim <sup>15</sup> 68, further comprising a catalyst reservoir in communication with said reaction vessel and temperature controlling structure capable of maintaining the temperature of said catalyst reservoir at about 50°C above the melting point of the compound having the highest melting point of a plurality of compounds which comprise said source of gaseous catalyst.

<sup>141</sup> 208. A cell according to claim <sup>15</sup> 66, further comprising a boat contained in said reaction vessel and temperature controlling structure capable of maintaining the temperature of said boat at about 50°C above the melting point of the compound having the highest melting point of a plurality of compounds which comprise said source of gaseous catalyst.

<sup>142</sup> 209. A cell according to claim <sup>27</sup> 78, further comprising temperature controlling structure capable of maintaining the temperature of said reaction vessel at about 50°C above the melting point of said gaseous catalyst.



<sup>143</sup> 210. A cell according to claim <sup>15</sup> 66, further comprising a catalyst reservoir containing said source of gaseous catalyst and being in communication with said reaction vessel, and temperature controlling structure capable of maintaining the temperature of said reaction vessel at about 50°C above the melting point of the compound having the highest melting point of a plurality of compounds which comprise said source of gaseous catalyst.

<sup>144</sup> 211. A cell according to claim <sup>15</sup> 66, further comprising a boat containing said source of gaseous catalyst and being disposed in said reaction vessel, and temperature controlling structure capable of maintaining the temperature of said reaction vessel at about 50°C above the melting point of the compound having the highest melting point of a plurality of compounds which comprise said source of gaseous catalyst.

<sup>145</sup> <sup>100</sup> 212. A method according to claim <sup>145</sup> 92, further comprising the step of forming said gaseous hydrogen atoms from a source of gaseous catalyst comprising an ionic compound which is resistant to hydrogen reduction.

<sup>145</sup> <sup>164</sup> 213. A method according to claim <sup>145</sup> 92, further comprising the step of forming said gaseous hydrogen atoms from a source of gaseous catalyst comprising an ionic compound which is resistant to hydrogen reduction and which is adapted to sublime, boil or become volatile when heated.

<sup>145</sup> <sup>162</sup> 214. A method according to claim <sup>145</sup> 92, further comprising the step of forming said gaseous compound from a source of gaseous catalyst comprising an ionic compound which is adapted to sublime, boil or become volatile when heated.

<sup>145</sup> <sup>163</sup> 215. A method according to claim <sup>145</sup> 92, further comprising the step of forming said gaseous compound from a source of gaseous catalyst comprising an ionic compound which is resistant to thermal degradation.

164  
216. A method according to claim 92, further comprising the step of forming said gaseous hydrogen atoms from a source of gaseous catalyst comprising a salt of rubidium or potassium.

165  
217. A method according to claim 92, further comprising the step of forming said gaseous hydrogen atoms from a source of gaseous catalyst comprising a salt that can form a vapor comprising ions when heated.

166  
218. A method according to claim 92, further comprising the step of forming said gaseous hydrogen atoms from a source of gaseous catalyst comprising a salt of rubidium selected from the group consisting of RbF, RbCl, RbBr, RbI, Rb<sub>2</sub>S<sub>2</sub>, RbOH, Rb<sub>2</sub>SO<sub>4</sub>, Rb<sub>2</sub>CO<sub>3</sub>, and Rb<sub>3</sub>PO<sub>4</sub>.

167  
219. A method according to claim 92, further comprising the step of forming said gaseous hydrogen atoms from a source of gaseous catalyst comprising a salt of potassium selected from the group consisting of KF, KCl, KBr, KI, K<sub>2</sub>S<sub>2</sub>, KOH, K<sub>2</sub>SO<sub>4</sub>, K<sub>2</sub>CO<sub>3</sub>, K<sub>3</sub>PO<sub>4</sub>, and K<sub>2</sub>GeF<sub>4</sub>.

168  
220. A method according to claim 92, further comprising the step of forming said gaseous hydrogen atoms from a source of gaseous catalyst comprising at least one metal selected from the group consisting of Mo, Ti, and Rb.

169  
221. A method according to claim 92, further comprising the step of forming said gaseous hydrogen atoms from a source of gaseous catalyst comprising at least one salt selected from the group consisting of MoI<sub>2</sub>, TiCl<sub>2</sub>, TiCl<sub>4</sub>, SnCl<sub>4</sub>, SiCl<sub>4</sub>, PrBr<sub>3</sub>, CaBr<sub>2</sub>, SrCl<sub>2</sub>, CrI<sub>2</sub>, Tbl<sub>3</sub>, SbCl<sub>3</sub>, CrF<sub>3</sub>, CoCl<sub>2</sub>, BiCl<sub>3</sub>, NiCl<sub>2</sub>, PdF<sub>2</sub>, InCl, LaCl<sub>3</sub>, DyCl<sub>3</sub>, LaI<sub>3</sub>, Hol<sub>3</sub>, KNO<sub>3</sub>, VF<sub>3</sub>, PbF<sub>2</sub>, VOCl, Pbl<sub>2</sub>, LuCl<sub>3</sub>, PbCl<sub>2</sub>, AsI<sub>3</sub>, Hol<sub>3</sub>, MoCl<sub>5</sub>, SnCl<sub>4</sub>, Sbl<sub>3</sub>, Cdl<sub>2</sub>, AgF<sub>2</sub>, AgF, LaI<sub>3</sub>, Erl<sub>3</sub>, VCl<sub>4</sub>, BCl<sub>3</sub>, FeCl<sub>3</sub>, TiCl<sub>3</sub>, Col<sub>2</sub>, CoF<sub>2</sub>, TII, TIF, BiBr<sub>3</sub>, ZnBr<sub>2</sub>,

AsI<sub>3</sub>, Dyl<sub>3</sub>, HoCl<sub>3</sub>, MgCl<sub>2</sub>, CrCl<sub>3</sub>, PrCl<sub>3</sub>, SrCl<sub>2</sub>, FeCl<sub>2</sub>, NiCl<sub>2</sub>, CuCl, SrCl<sub>2</sub>, MoCl<sub>2</sub>, YCl<sub>3</sub>, ZrCl<sub>4</sub>, CdI<sub>2</sub>, BaI<sub>2</sub>, HoI<sub>3</sub>, PbI<sub>2</sub>, PdF<sub>2</sub>, LiF, EuCl<sub>3</sub>, MgCl<sub>2</sub>, ErCl<sub>3</sub>, MgCl<sub>2</sub>, ErCl<sub>3</sub>, MgCl<sub>2</sub>, BiCl<sub>4</sub>, AlCl<sub>3</sub>, CaBr<sub>2</sub>, SmBr<sub>3</sub>, VaF<sub>3</sub>, LaCl<sub>3</sub>, GdI<sub>3</sub>, CrI<sub>2</sub>, MnI<sub>2</sub>, YbBr<sub>3</sub>, FeBr<sub>2</sub>, NiCl<sub>2</sub>, AgCl, ZnCl<sub>2</sub>, YbCl<sub>2</sub>, SeF<sub>4</sub>, SnCl<sub>4</sub>, SnF<sub>4</sub>, SbI<sub>3</sub>, BiI<sub>2</sub>, EuF<sub>3</sub>, and PbCl<sub>2</sub>.

190 145  
222. A method according to claim 92, wherein said gaseous catalyst comprises at least one ion selected from the group consisting of Mo<sup>2+</sup>, Ti<sup>2+</sup>, and Rb<sup>+</sup>.

191 145  
223. A method according to claim 92, wherein said gaseous catalyst comprises at least one pair of ions selected from the group consisting of: (Sn<sup>4+</sup>, Si<sup>4+</sup>), (Pr<sup>3+</sup>, Ca<sup>2+</sup>), (Sr<sup>2+</sup>, Cr<sup>2+</sup>), (Cr<sup>3+</sup>, Tb<sup>3+</sup>), (Sb<sup>3+</sup>, Co<sup>2+</sup>), (Bi<sup>3+</sup>, Ni<sup>2+</sup>), (Pd<sup>2+</sup>, In<sup>+</sup>), (La<sup>3+</sup>, Dy<sup>3+</sup>), (La<sup>3+</sup>, Ho<sup>3+</sup>), (K<sup>+</sup>, K<sup>+</sup>), (V<sup>3+</sup>, Pd<sup>2+</sup>), (Lu<sup>3+</sup>, Zn<sup>2+</sup>), (As<sup>3+</sup>, Ho<sup>3+</sup>), (Mo<sup>5+</sup>, Sn<sup>4+</sup>), (Sb<sup>3+</sup>, Cd<sup>2+</sup>), (Ag<sup>2+</sup>, Ag<sup>+</sup>), (La<sup>3+</sup>, Er<sup>3+</sup>), (V<sup>4+</sup>, B<sup>3+</sup>), (Fe<sup>3+</sup>, Ti<sup>3+</sup>), (Co<sup>2+</sup>, Ti<sup>+</sup>), (Bi<sup>3+</sup>, Zn<sup>2+</sup>), (As<sup>3+</sup>, Dy<sup>3+</sup>), (Ho<sup>3+</sup>, Mg<sup>2+</sup>), (K<sup>+</sup>, Rb<sup>+</sup>), (Cr<sup>3+</sup>, Pr<sup>3+</sup>), (Sr<sup>2+</sup>, Fe<sup>2+</sup>), (Ni<sup>2+</sup>, Cu<sup>+</sup>), (Sr<sup>2+</sup>, Mo<sup>2+</sup>), (Y<sup>3+</sup>, Zr<sup>4+</sup>), (Cd<sup>2+</sup>, Ba<sup>2+</sup>), (Ho<sup>3+</sup>, Pb<sup>2+</sup>), (Pb<sup>2+</sup>, Li<sup>+</sup>), (Eu<sup>3+</sup>, Mg<sup>2+</sup>), (Er<sup>3+</sup>, Mg<sup>2+</sup>), (Bi<sup>4+</sup>, Al<sup>3+</sup>), (Ca<sup>2+</sup>, Sm<sup>3+</sup>), (V<sup>3+</sup>, La<sup>3+</sup>), (Gd<sup>3+</sup>, Cr<sup>2+</sup>), (Mn<sup>2+</sup>, Ti<sup>+</sup>), (Yb<sup>3+</sup>, Fe<sup>2+</sup>), (Ni<sup>2+</sup>, Ag<sup>+</sup>), (Zn<sup>2+</sup>, Yb<sup>2+</sup>), (Se<sup>4+</sup>, Sn<sup>4+</sup>), (Sb<sup>3+</sup>, Bi<sup>2+</sup>), and (Eu<sup>3+</sup>, Pb<sup>2+</sup>).

192 145  
224. A method according to claim 92, further comprising the step of forming said gaseous catalyst from a source of gaseous catalyst comprising a salt of one or more cations and at least one anion selected from the group consisting of halides, sulfates, phosphates, carbonates, hydroxide and sulfides.

193 145  
225. A method according to claim 92, wherein said gaseous catalyst is selected to have a resonant adsorption with the energy released from said gaseous hydrogen atoms undergoing a transition to a lower energy state.

194 145  
226. A method according to claim 92, wherein said gaseous catalyst comprises potassium and has a net enthalpy of reaction of 27.28 eV.

<sup>175</sup>  
227. A method according to claim <sup>145</sup>92, wherein said gaseous catalyst has a net enthalpy of reaction of about 27.2 eV.

<sup>176</sup>  
228. A method according to claim <sup>145</sup>92, further comprising the step of combining a source of gaseous catalyst with a source of gaseous hydrogen atoms comprising at least one of a hydrocarbon or water, and providing combustion which volatilizes said source of gaseous catalyst to form said gaseous catalyst and provide said gaseous hydrogen atoms.

<sup>177</sup>  
229. A method according to claim <sup>145</sup>92, further comprising the step of forming a source of gaseous catalyst or said gaseous catalyst in situ.

<sup>178</sup>  
230. A method according to claim <sup>177</sup>229, wherein said step of forming said source of gaseous catalyst or said gaseous catalyst in situ comprises the ionization of a reactant.

<sup>179</sup>  
231. A method according to claim <sup>178</sup>230, wherein said step of ionization comprises thermal ionization of said reactant.

<sup>180</sup>  
232. A method according to claim <sup>178</sup>230, wherein said step of ionization comprises chemical ionization of said reactant.

<sup>181</sup>  
233. A method according to claim <sup>180</sup>232, wherein said step of chemical ionization comprises oxidation or reduction of said reactant.

<sup>182</sup>  
234. A method according to claim <sup>145</sup>92, further comprising the step of volatilizing a source of catalyst to form said gaseous catalyst utilizing energy from at least one of heat,

electron-beam energy, photon energy, acoustic energy, electric field, or magnetic field.

<sup>183</sup>  
235. A method according to claim 92, wherein said the step of volatilizing a source of catalyst comprises the step of heating a filament coated with said source of gaseous catalyst.

<sup>184</sup>  
236. A method according to claim 92, further comprising adding a source of catalyst to said reaction vessel and heating said source of catalyst to form said gaseous catalyst.

C10 <sup>185</sup>  
237. A method according to claim 92, further comprising the step of providing a source of catalyst in a catalyst reservoir comprising a container separate from said vessel and said container communicates with said reaction vessel.

<sup>186</sup>  
238. A method according to claim 92, further comprising the step of providing a source of catalyst in a boat contained within said reaction vessel.

<sup>187</sup>  
239. A method according to claim 92, wherein said step of providing hydrogen atoms comprises the steps of disassociating a hydrogen containing compound into hydrogen atoms.

<sup>188</sup>  
240. A method according to claim 92, wherein said step of providing hydrogen atoms comprises the steps of passing a hydrogen containing gas over a hot filament.

<sup>189</sup>  
241. A method according to claim 92, wherein said step of providing hydrogen atoms comprises the steps of passing a hydrogen containing gas over a hot grid.

<sup>190</sup>  
~~242~~. A method according to claim <sup>145</sup>~~92~~, wherein said step of providing hydrogen atoms comprises the steps of passing a hydrogen containing gas through a tungsten capillary heated by electron bombardment.

<sup>191</sup>  
~~243~~. A method according to claim <sup>145</sup>~~92~~, wherein said step of providing hydrogen atoms comprises the steps of maintaining a hydride under nonequilibrium conditions.

<sup>192</sup>  
~~244~~. A method according to claim <sup>147</sup>~~94~~, wherein said second catalyst comprises at least one element selected from the group consisting of transition elements, inner transition elements, precious metals, refractory metals, lanthanides, actinides and activated charcoal.

<sup>193</sup>  
~~245~~. A method according to claim <sup>147</sup>~~94~~, wherein said second catalyst is selected from the group consisting of an element, compound, alloy or mixture of transition elements, inner transition elements, iron, platinum, palladium, zirconium, vanadium, nickel, titanium, Sc, Cr, Mn, Co, Cu, Zn, Y, Nb, Mo, Tc, Ru, Rh, Ag, Cd, La, Hf, Ta, W, Re, Os, Ir, Au, Hg, Ce, Pr, Nd, Pm, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Vb, Lu, Th, Pa, U, activated charcoal, and intercalated Cs carbon.

<sup>194</sup>  
~~246~~. A method according to claim <sup>147</sup>~~94~~, further comprising the step of utilizing a hot filament or hot grid to disassociate a hydrogen containing gas into gaseous hydrogen atoms and to heat said second catalyst.

<sup>195</sup>  
~~247~~. A method according to claim <sup>147</sup>~~94~~, further comprising the step of controlling the power output of said cell.

<sup>196</sup>  
~~248~~. A method according to claim <sup>147</sup>~~94~~, wherein said step of controlling the power output of said cell comprises controlling the temperature of said second catalyst.

<sup>197</sup> 249. A method according to claim ~~248~~<sup>196</sup>, wherein said step of controlling the temperature of said second catalyst comprises utilizing a heated filament or grid.

<sup>198</sup> 250. A method according to claim ~~92~~<sup>145</sup>, further comprising the step of forming said gaseous hydrogen atoms from at least one source of gaseous hydrogen atoms selected from the group consisting of hydrogen gas, water, hydrides, metal-hydrogen solutions, and hydrocarbons.

<sup>199</sup> 251. A method according to claim ~~92~~<sup>145</sup>, wherein said step of providing gaseous hydrogen atoms comprises pyrolyzing hydrocarbons or water.

<sup>200</sup> 252. A method according to claim ~~92~~<sup>145</sup>, further comprising the step of reforming hydrocarbons to at least one of gaseous molecular and gaseous atomic hydrogen.

<sup>201</sup> 253. A method according to claim ~~92~~<sup>145</sup>, further comprising the step of disassociating hydrogen containing molecules using UV light to form said gaseous hydrogen atoms.

<sup>202</sup> 254. A method according to claim ~~92~~<sup>145</sup>, further comprising the step of controlling the amount of gaseous hydrogen provided in said reaction vessel.

<sup>203</sup> 255. A method according to claim ~~92~~<sup>145</sup>, further comprising the step of controlling the flow of a source of gaseous hydrogen atoms or said gaseous hydrogen atoms from a chamber to said reaction vessel.

<sup>204</sup> 256. A method according to claim ~~92~~<sup>145</sup>, further comprising the step of utilizing a valve for controlling the flow of gaseous hydrogen or source of gaseous hydrogen from said reaction vessel.

205  
257. A method according to claim 92, further comprising the step of controlling the flow of gaseous hydrogen from said reaction vessel.

206  
258. A method according to claim 92, further comprising the step of utilizing a vacuum pump for controlling the flow of gaseous hydrogen from said reaction vessel.

207  
259. A method according to claim 92, further comprising the step of utilizing a valve for controlling the flow of gaseous hydrogen from a chamber into said reaction vessel.

208  
260. A method according to claim 92, further comprising controlling the partial pressure of said gaseous hydrogen atoms.

C10  
209  
261. A method according to claim 92, wherein a partial pressure of said gaseous hydrogen atoms or source of gaseous hydrogen atoms in said reaction vessel is maintained within the range of  $10^{-3}$  atmospheres to 100 atmospheres.

210  
262. A method according to claim 92, further comprising controlling the amount of gaseous catalyst or a source of gaseous catalyst introduced into said reaction vessel.

211  
263. A method according to claim 92, further comprising controlling the flow of gaseous catalyst or a source of gaseous catalyst from a catalyst reservoir containing gaseous catalyst or a source of gaseous catalyst to said reaction vessel.

212  
264. A method according to claim 92, further comprising controlling the flow of gaseous catalyst or a source of gaseous catalyst from a boat containing gaseous catalyst or a source of gaseous catalyst.



213 145  
265. A method according to claim 92, further comprising the step of controlling the flow of said gaseous catalyst or a source of gaseous catalyst from said reaction vessel.

214 145  
266. A method according to claim 92, further comprising the step of controlling the vapor pressure of said gaseous catalyst or a source of gaseous catalyst in said reaction vessel.

215 145  
267. A method according to claim 92, wherein a vapor pressure of said gaseous catalyst or a source of gaseous catalyst is maintained at about 50 to 210 millitorr.

216 145  
268. A method according to claim 92, further comprising using a vacuum pump to control the flow of said gaseous catalyst or a source of gaseous catalyst from said reaction vessel.

217 145  
269. A method according to claim 92, further comprising using a valve to control the flow of a source of gaseous catalyst or a source of gaseous catalyst from a catalyst reservoir into said reaction vessel.

218 145  
270. A method according to claim 92, further comprising using a valve to control the flow of a source of gaseous catalyst or said catalyst from said reaction vessel.

219 145  
271. A method according to claim 92, further comprising the step of supplying a nonreactive gas to said reaction vessel.

220 219  
272. A method according to claim 271, further comprising the step of controlling the vapor pressure of said nonreactive gas in said reaction vessel.

221 219  
273. A method according to claim 271, further comprising the step of controlling the flow of said nonreactive gas supplied to said reaction vessel.

<sup>222</sup>  
274. A method according to claim <sup>219</sup>~~271~~, further comprising the step of controlling the amount of said nonreactive gas released from said reaction vessel.

<sup>223</sup>  
275. A method according to claim <sup>219</sup>~~271~~, further comprising utilizing a vacuum pump for controlling the flow of said nonreactive gas from said reaction vessel.

<sup>224</sup>  
276. A method according to claim <sup>219</sup>~~271~~, further comprising the step of utilizing a valve for controlling the flow of said nonreactive gas from said reaction vessel.

<sup>225</sup>  
277. A method according to claim <sup>219</sup>~~271~~, further comprising the step of utilizing a valve for controlling the flow of said nonreactive gas into said reaction vessel.

<sup>226</sup>  
278. A method according to claim <sup>145</sup>~~92~~, further comprising the step of controlling the vapor pressure of said gaseous catalyst in said reaction vessel.

<sup>227</sup>  
279. A method according to claim <sup>226</sup>~~278~~, wherein said step of controlling the vapor pressure of said gaseous catalyst comprises controlling the temperature in a catalyst reservoir containing a source of gaseous catalyst or said gaseous catalyst and being in communication with said reaction vessel, and controlling the flow of gaseous catalyst from said catalyst reservoir.

<sup>228</sup>  
280. A method according to claim <sup>226</sup>~~278~~, wherein said step of controlling the vapor pressure of said gaseous catalyst comprises controlling the temperature in a boat containing a source of gaseous catalyst or said gaseous catalyst and being contained in said reaction vessel, and controlling the flow of gaseous catalyst from said boat.

229 281. A method according to claim 92, further comprising the step of controlling the temperature in a catalyst reservoir containing a source of gaseous catalyst or said gaseous catalyst and being in communication with said reaction vessel.

230 282. A method according to claim 92, further comprising the step of controlling the temperature in a boat containing a source of gaseous catalyst or said gaseous catalyst and being contained in said reaction vessel.

231 283. A method according to claim 92, wherein the reaction to provide a net enthalpy of about  $27 (p/2)$  eV, where  $p$  is a positive integer greater than 1, comprises an electrochemical, chemical, photochemical, thermal, free radical, sonic, nuclear, inelastic photon, or particle scattering reaction, or mixtures thereof.

232 284. A method according to claim 92, wherein a pressure in said reaction vessel is maintained within the range of  $10^{-3}$  atmospheres to 100 atmospheres.

233 285. A method according to claim 92, wherein said reaction occurring at a pressure less than atmospheric pressure.

234 286. A method according to claim 92, further comprising the step of releasing hydrogen atoms from said reaction vessel having a binding energy of about  $E_b = 13.6/n^2$  eV, where  $n$  is a fraction whose numerator is 1 and denominator is an integer greater than 1 or a compound containing said hydrogen atoms.

235 287. A method according to claim 92, further comprising the step of adsorbing said released energy.

236 288. A method according to claim 92, further comprising the step of converting energy released from said hydrogen atom into electrical energy.

237  
239. A method according to claim 92, wherein said reaction step is conducted in an internal combustion chamber.

238  
290. A method according to claim 92, wherein said internal combustion chamber is an engine cylinder.

239  
291. A method according to claim 92, further comprising the step of controlling the power output of said cell.

C10  
240  
292. A method according to claim 291, wherein said step of controlling the power output of said cell comprises controlling the amount of said gaseous catalyst present in said reaction vessel.

241  
293. A method according to claim 292, wherein said step of controlling the amount of gaseous catalyst comprises controlling the temperature of said reaction vessel and selecting said gaseous catalyst or source of gaseous catalyst to have a vapor pressure dependent upon the temperature of said reaction vessel.

242  
294. A method according to claim 292, wherein said step of controlling the amount of gaseous catalyst comprises controlling the temperature of a catalyst reservoir containing a source of gaseous catalyst or said gaseous catalyst and being in communication with said reaction vessel, and selecting said gaseous catalyst to have a vapor pressure dependent upon the temperature of said catalyst reservoir.

243  
295. A method according to claim 292, wherein said step of controlling the amount of gaseous catalyst comprises controlling the flow of said source of gaseous catalyst or gaseous catalyst from said catalyst reservoir into said reaction vessel.

244  
296. A method according to claim 240, wherein said step of controlling the amount of gaseous catalyst comprises controlling the flow of said source of gaseous catalyst or gaseous catalyst from said reaction vessel.

245  
297. A method according to claim 240, wherein said step of controlling the amount of gaseous catalyst comprises controlling the temperature of a boat containing a source of gaseous catalyst or said gaseous catalyst and being contained in said reaction vessel, and selecting said gaseous catalyst to have a vapor pressure dependent upon the temperature of said boat.

246  
298. A method according to claim 239, wherein said step of controlling the power output of said cell comprises controlling the amount of said gaseous hydrogen atoms present in said reaction vessel.

247  
299. A method according to claim 246, wherein said step of controlling the amount of said gaseous hydrogen atoms comprises controlling the flow of gaseous hydrogen atoms or source of gaseous hydrogen atoms into said reaction vessel.

248  
300. A method according to claim 246, wherein said step of controlling the amount of said source of gaseous hydrogen atoms or gaseous hydrogen atoms comprises controlling the flow of said source of gaseous hydrogen atoms or gaseous hydrogen atoms from said reaction vessel.

249  
301. A method according to claim 246, wherein said step of controlling the amount of said source of gaseous hydrogen atoms or gaseous hydrogen atoms comprises controlling the temperature of a second catalyst for dissociating a hydrogen containing compound into gaseous hydrogen atoms.

249  
302. A method according to claim 301, wherein said step of controlling the temperature of a second catalyst for dissociating a hydrogen containing compound into gaseous hydrogen atoms comprises controlling the power dissipated in a second catalyst heater.

251 239  
303. A method according to claim 291, wherein said step of controlling the power output of said cell comprises controlling the amount of nonreactive gas in said reaction vessel.

E 252 251  
304. A method according to claim 304, wherein said step of controlling the amount of nonreactive gas in said reaction vessel comprises controlling the flow of nonreactive gas into said reaction vessel.

C10 253 252  
305. A method according to claim 304, wherein said step of controlling the amount of nonreactive gas in said reaction vessel comprises controlling the flow of nonreactive gas from said reaction vessel.

254 239  
306. A method according to claim 291, wherein said step of controlling the power output of said cell comprises controlling the temperature of a source of gaseous catalyst.

255 239  
307. A method according to claim 291, wherein said step of controlling the power output of said cell comprises controlling the flow of a hydrogen containing gas over at least one of a hot filament, a tungsten capillary heated by electron bombardment, or an inductively coupled plasma flow.

256 239  
308. A method according to claim 291, wherein said step of controlling the power output of said cell comprises controlling the power dissipated in an inductively coupled plasma flow tube, hot filament or grid, or tungsten capillary heated by electron bombardment.

257 239  
309. A method according to claim 291, wherein said step of controlling the power output of said cell comprises controlling the temperature of a hot filament or tungsten capillary heated by electron bombardment over which a hydrogen containing gas flows.

258 239  
310. A method according to claim 291, wherein said step of controlling the power output of said cell comprises controlling the temperature of a hydride maintained under nonequilibrium conditions.

259 145  
311. A method according to claim 92, wherein a temperature in said reaction vessel is maintained at a higher temperature than in a catalyst reservoir in communication with said reaction vessel or a boat contained within said reaction vessel.

260 145  
312. A method according to claim 92, further comprising the step of measuring the temperature of a catalyst reservoir in communication with said reaction vessel or a boat contained in said reaction vessel.

261 145  
313. A method according to claim 92, further comprising the step of measuring the temperature of a source of said gaseous catalyst contained in a catalyst reservoir in communication with said reaction vessel or a boat contained within said reaction vessel.

262 145  
314. A method according to claim 92, further comprising the step of measuring the temperature of a chamber containing a source of said hydrogen atoms in communication with said reaction vessel.

263 145  
315. A method according to claim 92, further comprising the step of measuring the temperature of a source of said gaseous hydrogen atoms.

264 147  
316. A method according to claim 94, further comprising the step of measuring the temperature of said second catalyst.

265 145  
317. A method according to claim 92, further comprising the step of controlling the temperature of said reaction vessel.

266 145  
318. A method according to claim 92, further comprising utilizing a nebulizer or atomizer to form said gaseous catalyst.

C10 267 145  
319. A method according to claim 92, further comprising the step of measuring the pressure in said reaction vessel.

268 145  
320. A method according to claim 92, further comprising the step of controlling the pressure in said reaction vessel.

269 145  
321. A method according to claim 92, further comprising the step of measuring the hydrogen pressure in said reaction vessel.

270 145  
322. A method according to claim 92, further comprising the step of measuring the gaseous catalyst pressure in said reaction vessel.

271 145  
323. A method according to claim 92, further comprising the step of converting energy released from said gaseous hydrogen atoms into electrical energy.

272 145  
324. A method according to claim 92, further comprising controlling the pressure of said gaseous catalyst by controlling the amount of said source of catalyst being added to said reaction vessel.



<sup>273</sup>  
325. A cell for extracting energy from hydrogen atoms comprising:  
a reaction vessel;  
a source of gaseous hydrogen atoms; and  
a source of a gaseous catalyst having a net enthalpy of reaction of about  $27(p/2)$  eV, where p is an integer greater than 1.

<sup>274</sup>  
326. A cell for extracting energy from hydrogen atoms comprising:  
a reaction vessel;  
a chamber communicating with said vessel, said chamber containing gaseous hydrogen atoms or a source of said hydrogen atoms; and  
a catalyst reservoir communicating with said reaction vessel or a boat contained in said reaction vessel, said catalyst reservoir or boat containing a gaseous catalyst having a net enthalpy of reaction of about  $27 * (p/2)$  eV, where p is an integer greater than 1, or a source of said gaseous catalyst.

C10  
<sup>275</sup>  
327. A cell according to claim <sup>274</sup>326, wherein said source of gaseous catalyst comprises an ionic compound which is resistant to hydrogen reduction.

<sup>276</sup>  
328. A cell according to claim <sup>274</sup>326, wherein said source of gaseous catalyst comprises an ionic compound which is resistant to hydrogen reduction and which is adapted to sublime, boil or become volatile when heated.

<sup>277</sup>  
329. A cell according to claim <sup>274</sup>326, wherein said source of gaseous catalyst comprises an ionic compound which is adapted to sublime, boil or become volatile when heated.

<sup>278</sup>  
330. A cell according to claim <sup>274</sup>326, wherein said source of gaseous catalyst comprises an ionic compound which is resistant to thermal degradation.

279 274  
331. A cell according to claim 326, wherein said source of gaseous catalyst comprises a salt of rubidium or potassium.

280 274  
332. A cell according to claim 326, wherein said source of gaseous catalyst comprises a salt that can form a vapor comprising ions when heated.

281 274  
333. A cell according to claim 326, wherein said source of gaseous catalyst comprises a salt of rubidium selected from the group consisting of RbF, RbCl, RbBr, RbI, Rb<sub>2</sub>S<sub>2</sub>, RbOH, Rb<sub>2</sub>SO<sub>4</sub>, Rb<sub>2</sub>CO<sub>3</sub>, and Rb<sub>3</sub>PO<sub>4</sub>.

282 274  
334. A cell according to claim 326, wherein said source of gaseous catalyst comprises a salt of potassium selected from the group consisting of KF, KCl, KBr, KI, K<sub>2</sub>S<sub>2</sub>, KOH, K<sub>2</sub>SO<sub>4</sub>, K<sub>2</sub>CO<sub>3</sub>, K<sub>3</sub>PO<sub>4</sub>, and K<sub>2</sub>GeF<sub>4</sub>.

283 274  
335. A cell according to claim 326, wherein said source of gaseous catalyst comprises at least one metal selected from the group consisting of Mo, Ti, and Rb.

284 274  
336. A cell according to claim 326, wherein said source of gaseous catalyst comprises at least one salt selected from the group consisting of MoI<sub>2</sub>, TiCl<sub>2</sub>, TiCl<sub>4</sub>, SnCl<sub>4</sub>, SiCl<sub>4</sub>, PrBr<sub>3</sub>, CaBr<sub>2</sub>, SrCl<sub>2</sub>, CrI<sub>2</sub>, Tbl<sub>3</sub>, SbCl<sub>3</sub>, CrF<sub>3</sub>, CoCl<sub>2</sub>, BiCl<sub>3</sub>, NiCl<sub>2</sub>, PdF<sub>2</sub>, InCl, LaCl<sub>3</sub>, DyCl<sub>3</sub>, LaI<sub>3</sub>, Hol<sub>3</sub>, KNO<sub>3</sub>, VF<sub>3</sub>, PbF<sub>2</sub>, VOCl, Pbl<sub>2</sub>, LuCl<sub>3</sub>, PbCl<sub>2</sub>, AsI<sub>3</sub>, Hol<sub>3</sub>, MoCl<sub>5</sub>, SnCl<sub>4</sub>, Sbl<sub>3</sub>, Cdl<sub>2</sub>, AgF<sub>2</sub>, AgF, Lal<sub>3</sub>, Erl<sub>3</sub>, VCl<sub>4</sub>, BCl<sub>3</sub>, FeCl<sub>3</sub>, TiCl<sub>3</sub>, Col<sub>2</sub>, CoF<sub>2</sub>, TII, TIF, BiBr<sub>3</sub>, ZnBr<sub>2</sub>, AsI<sub>3</sub>, Dyl<sub>3</sub>, HoCl<sub>3</sub>, MgCl<sub>2</sub>, CrCl<sub>3</sub>, PrCl<sub>3</sub>, SrCl<sub>2</sub>, FeCl<sub>2</sub>, NiCl<sub>2</sub>, CuCl, SrCl<sub>2</sub>, MoCl<sub>2</sub>, YCl<sub>3</sub>, ZrCl<sub>4</sub>, Cdl<sub>2</sub>, Bal<sub>2</sub>, Hol<sub>3</sub>, Pbl<sub>2</sub>, PdF<sub>2</sub>, LiF, EuCl<sub>3</sub>, MgCl<sub>2</sub>, ErCl<sub>3</sub>, MgCl<sub>2</sub>, ErCl<sub>3</sub>, MgCl<sub>2</sub>, BiCl<sub>4</sub>, AlCl<sub>3</sub>, CaBr<sub>2</sub>, SmBr<sub>3</sub>, VaF<sub>3</sub>, LaCl<sub>3</sub>, Gdl<sub>3</sub>, Crl<sub>2</sub>, Mnl<sub>2</sub>, YbBr<sub>3</sub>, FeBr<sub>2</sub>, NiCl<sub>2</sub>, AgCl, ZnCl<sub>2</sub>, YbCl<sub>2</sub>, SeF<sub>4</sub>, SnCl<sub>4</sub>, SnF<sub>4</sub>, Sbl<sub>3</sub>, Bil<sub>2</sub>, EuF<sub>3</sub>, and PbCl<sub>2</sub>.

285 274  
337. A cell according to claim 326, wherein said gaseous catalyst comprises at least one ion selected from the group consisting of  $\text{Mo}^{2+}$ ,  $\text{Ti}^{2+}$ , and  $\text{Rb}^{+}$ .

286 274  
338. A cell according to claim 326, wherein said gaseous catalyst comprises at least one pair of ions selected from the group consisting of: ( $\text{Sn}^{4+}$ ,  $\text{Si}^{4+}$ ), ( $\text{Pr}^{3+}$ ,  $\text{Ca}^{2+}$ ), ( $\text{Sr}^{2+}$ ,  $\text{Cr}^{2+}$ ), ( $\text{Cr}^{3+}$ ,  $\text{Tb}^{3+}$ ), ( $\text{Sb}^{3+}$ ,  $\text{Co}^{2+}$ ), ( $\text{Bi}^{3+}$ ,  $\text{Ni}^{2+}$ ), ( $\text{Pd}^{2+}$ ,  $\text{In}^{+}$ ), ( $\text{La}^{3+}$ ,  $\text{Dy}^{3+}$ ), ( $\text{La}^{3+}$ ,  $\text{Ho}^{3+}$ ), ( $\text{K}^{+}$ ,  $\text{K}^{+}$ ), ( $\text{V}^{3+}$ ,  $\text{Pd}^{2+}$ ), ( $\text{Lu}^{3+}$ ,  $\text{Zn}^{2+}$ ), ( $\text{As}^{3+}$ ,  $\text{Ho}^{3+}$ ), ( $\text{Mo}^{5+}$ ,  $\text{Sn}^{4+}$ ), ( $\text{Sb}^{3+}$ ,  $\text{Cd}^{2+}$ ), ( $\text{Ag}^{2+}$ ,  $\text{Ag}^{+}$ ), ( $\text{La}^{3+}$ ,  $\text{Er}^{3+}$ ), ( $\text{V}^{4+}$ ,  $\text{B}^{3+}$ ), ( $\text{Fe}^{3+}$ ,  $\text{Ti}^{3+}$ ), ( $\text{Co}^{2+}$ ,  $\text{Ti}^{+}$ ), ( $\text{Bi}^{3+}$ ,  $\text{Zn}^{2+}$ ), ( $\text{As}^{3+}$ ,  $\text{Dy}^{3+}$ ), ( $\text{Ho}^{3+}$ ,  $\text{Mg}^{2+}$ ), ( $\text{K}^{+}$ ,  $\text{Rb}^{+}$ ), ( $\text{Cr}^{3+}$ ,  $\text{Pr}^{3+}$ ), ( $\text{Sr}^{2+}$ ,  $\text{Fe}^{2+}$ ), ( $\text{Ni}^{2+}$ ,  $\text{Cu}^{+}$ ), ( $\text{Sr}^{2+}$ ,  $\text{Mo}^{2+}$ ), ( $\text{Y}^{3+}$ ,  $\text{Zr}^{4+}$ ), ( $\text{Cd}^{2+}$ ,  $\text{Ba}^{2+}$ ), ( $\text{Ho}^{3+}$ ,  $\text{Pb}^{2+}$ ), ( $\text{Pb}^{2+}$ ,  $\text{Li}^{+}$ ), ( $\text{Eu}^{3+}$ ,  $\text{Mg}^{2+}$ ), ( $\text{Er}^{3+}$ ,  $\text{Mg}^{2+}$ ), ( $\text{Bi}^{4+}$ ,  $\text{Al}^{3+}$ ), ( $\text{Ca}^{2+}$ ,  $\text{Sm}^{3+}$ ), ( $\text{V}^{3+}$ ,  $\text{La}^{3+}$ ), ( $\text{Gd}^{3+}$ ,  $\text{Cr}^{2+}$ ), ( $\text{Mn}^{2+}$ ,  $\text{Ti}^{+}$ ), ( $\text{Yb}^{3+}$ ,  $\text{Fe}^{2+}$ ), ( $\text{Ni}^{2+}$ ,  $\text{Ag}^{+}$ ), ( $\text{Zn}^{2+}$ ,  $\text{Yb}^{2+}$ ), ( $\text{Se}^{4+}$ ,  $\text{Sn}^{4+}$ ), ( $\text{Sb}^{3+}$ ,  $\text{Bi}^{2+}$ ), and ( $\text{Eu}^{3+}$ ,  $\text{Pb}^{2+}$ ).

287 274  
339. A cell according to claim 326, wherein said source of gaseous catalyst comprises a salt of one or more cations and at least one anion selected from the group consisting of halides, sulfates, phosphates, carbonates, hydroxide and sulfides.

288 274  
340. A cell according to claim 326, wherein said gaseous catalyst comprises hydrogen atoms having a binding energy of about  $E_b = 13.6/n^2$  eV, where n is a fraction whose numerator is 1 and denominator is an integer greater than 1.

289 274  
341. A cell according to claim 326, wherein said gaseous catalyst comprises potassium and has a net enthalpy of reaction of 27.28 eV.

290 274  
342. A cell according to claim 326, wherein said gaseous catalyst has a net enthalpy of reaction of about 27.2 eV.

291 274  
343. A cell according to claim 326, wherein said cell comprises said source of said gaseous catalyst combined with at least one of a hydrocarbon or water disposed

such that said gaseous catalyst and said gaseous hydrogen atoms are capable being formed during combustion.

<sup>292</sup>  
~~344~~. A cell according to claim <sup>274</sup>~~326~~, further comprising a means for converting said source of catalyst to said gaseous catalyst.

<sup>293</sup>  
~~345~~. A cell according to claim <sup>292</sup>~~344~~, wherein said means for converting said source of catalyst to said gaseous catalyst comprises at least one of heat, electron-beam energy, photon energy, acoustic energy, electric field, or magnetic field.

<sup>294</sup>  
~~346~~. A cell according to claim <sup>274</sup>~~326~~, further comprising a filament coated with said source of gaseous catalyst.

<sup>295</sup>  
~~347~~. A cell according to claim <sup>274</sup>~~326~~, wherein said source of gaseous hydrogen atoms is selected from the group consisting of hydrogen gas, water, hydrides, metal-hydrogen solutions, and hydrocarbons.

<sup>296</sup>  
~~348~~. A cell according to claim <sup>274</sup>~~326~~, wherein said source of hydrogen atoms comprises a hot filament and a hydrogen containing gas stream.

<sup>297</sup>  
~~349~~. A cell according to claim <sup>274</sup>~~326~~, wherein said source of hydrogen atoms comprises a hot grid and a hydrogen containing gas stream.

<sup>298</sup>  
~~350~~. A cell according to claim <sup>274</sup>~~326~~, wherein said source of hydrogen atoms comprises a heated tungsten capillary and a hydrogen containing gas stream.

<sup>299</sup>  
~~351~~. A cell according to claim <sup>274</sup>~~326~~, wherein said source of hydrogen atoms comprises a hydride maintained under nonequilibrium conditions.

300  
352. A cell according to claim 326, wherein said source of hydrogen atoms comprises an inductively coupled plasma flow tube and a hydrogen gas containing stream.

301  
353. A cell according to claim 326, wherein said source of hydrogen atoms comprises a hydrogen containing gas stream and a second catalyst for disassociating said hydrogen containing gas stream into free hydrogen atoms.

302  
354. A cell according to claim 326, wherein said source of hydrogen atoms comprises an internal combustion engine.

C10  
303  
355. A cell according to claim 353, wherein said second catalyst comprises at least one element selected from the group consisting of transition elements, inner transition elements, precious metals, refractory metals, lanthanides, actinides, and activated charcoal.

304  
356. A cell according to claim 353, wherein said second catalyst comprises at least one selected from the group consisting of an element, compound, alloy or mixture of transition elements, inner transition elements, iron, platinum, palladium, zirconium, vanadium, nickel, titanium, Sc, Cr, Mn, Co, Cu, Zn, Y, Nb, Mo, Tc, Ru, Rh, Ag, Cd, La, Hf, Ta, W, Re, Os, Ir, Au, Hg, Ce, Pr, Nd, Pm, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Vb, Lu, Th, Pa, U, activated charcoal, and intercalated Cs carbon.

305  
357. A cell according to claim 353, wherein said second catalyst is treated with an aqueous solution of  $K_2CO_3$  and  $H_2O_2$ .

306  
358. A cell according to claim 353, further comprising a heater to heat said second catalyst.

<sup>307</sup>359. A cell according to claim <sup>301</sup>353, further comprising a filament or grid constructed and arranged to dissociate hydrogen and to heat said second catalyst.

<sup>308</sup>360. A cell according to claim <sup>301</sup>353, further comprising means for controlling the power output of said cell.

<sup>309</sup>361. A cell according to claim <sup>309</sup>360, wherein said means for controlling the power output of said cell comprises means for controlling the temperature of said second catalyst.

<sup>310</sup>362. A cell according to claim <sup>309</sup>361, wherein said means for controlling the temperature of said second catalyst comprises a filament or grid.

C10 <sup>311</sup>363. A cell according to claim <sup>301</sup>353, further comprising a temperature controlling structure capable of maintaining a selected atomic hydrogen partial pressure by controlling the temperature of said second catalyst.

<sup>312</sup>364. A cell according to claim <sup>311</sup>363, wherein said temperature controlling structure is at least one selected from the group consisting of an internal heater, an external heater, the catalysis of hydrogen, and a heat exchanger which removes energy from the cell.

<sup>313</sup>365. A cell according to claim <sup>274</sup>326, wherein said source of hydrogen atoms comprises a means for pyrolysis of hydrocarbons or water.

<sup>314</sup>366. A cell according to claim <sup>274</sup>326, further comprising means to reform hydrocarbons to at least one of gaseous molecular and gaseous atomic hydrogen.

<sup>1315</sup> 367. <sup>274</sup> A cell according to claim ~~326~~, further comprising a source of UV light for disassociating hydrogen containing molecules to form said gaseous hydrogen atoms.

<sup>316</sup> 368. <sup>274</sup> A cell according to claim ~~326~~, further comprising a flow control means for controlling the flow of said source of gaseous hydrogen atoms or said gaseous hydrogen atoms from said chamber to said reaction vessel.

<sup>317</sup> 369. <sup>316</sup> A cell according to claim ~~368~~, wherein said flow control means comprises a valve.

<sup>318</sup> 370. <sup>274</sup> A cell according to claim ~~326~~, further comprising a flow control means for controlling the flow of hydrogen from said reaction vessel.

C10 <sup>319</sup> 371. <sup>425 318</sup> A cell according to claim ~~370~~, wherein said flow control means comprises a valve.

<sup>320</sup> 372. <sup>274</sup> A cell according to claim ~~326~~, further comprising a vacuum pump constructed and arranged for controlling the flow of hydrogen from said reaction vessel.

<sup>321</sup> 373. <sup>274</sup> A cell according to claim ~~326~~, further comprising a flow control means for controlling the flow of said gaseous catalyst or a source of gaseous catalyst from said catalyst reservoir to said reaction vessel.

<sup>322</sup> 374. <sup>425 321</sup> A cell according to claim ~~373~~, wherein said flow control means comprises a valve.

<sup>323</sup> 375. <sup>274</sup> A cell according claim ~~326~~, further comprising means for controlling the flow of catalyst from said reaction vessel.

<sup>324</sup> 376. <sup>274</sup> A cell according to claim ~~326~~, further comprising a valve constructed and arranged for controlling the flow of said catalyst from said reaction vessel.

<sup>325</sup>  
~~377~~. A cell according to claim <sup>274</sup>~~326~~, further comprising a vacuum pump constructed and arranged for controlling the flow of said gaseous catalyst or source of gaseous catalyst from said reaction vessel.

<sup>326</sup>  
~~378~~. A cell according to claim <sup>274</sup>~~326~~, further comprising a nonreactive gas.

<sup>327</sup>  
~~379~~. A cell according to claim <sup>274</sup>~~326~~, further comprising a means for controlling the amount of a nonreactive gas in said vessel.

<sup>328</sup>  
~~380~~. A cell according to claim <sup>274</sup>~~326~~, further comprising flow control means for controlling the flow of a nonreactive gas into said reaction vessel.

C10  
<sup>329</sup>  
~~381~~. A cell according to claim <sup>328</sup>~~380~~, wherein said means for controlling the amount of nonreactive gas in said vessel comprises a valve constructed and arranged to regulate the release of said nonreactive gas from said reaction vessel.

<sup>330</sup>  
~~382~~. A cell according to claim <sup>274</sup>~~326~~, further comprising a valve constructed and arranged for controlling the flow of a nonreactive gas from said reaction vessel.

<sup>331</sup>  
~~383~~. A cell according to claim <sup>274</sup>~~326~~, further comprising a vacuum pump constructed and arranged for controlling the flow of a nonreactive gas from said reaction vessel.

<sup>332</sup>  
~~384~~. A cell according to claim <sup>274</sup>~~326~~, further comprising a pump in communication with said reaction vessel.

<sup>333</sup>  
~~385~~. A cell according to claim <sup>274</sup>~~326~~, further comprising structure for controlling the vapor pressure of said catalyst.



334  
386. A cell according to claim 385, wherein said structure for controlling the vapor pressure of said catalyst comprises a heater constructed and arranged to control the temperature of said catalyst reservoir or said boat.

335  
387. A cell according to claim 385, wherein said structure for controlling the vapor pressure of said catalyst comprises a heater constructed and arranged to control the temperature of said reaction chamber.

336  
388. A cell according to claim 326, further comprising structure for maintaining a selected vapor pressure of said gaseous catalyst.

337  
389. A cell according to claim 388, wherein said structure for maintaining a selected vapor pressure of said gaseous catalyst comprises a valve constructed and arranged for controlling the flow of said source of gaseous catalyst or gaseous catalyst from said catalyst reservoir and a valve constructed and arranged for controlling the flow of said source of gaseous catalyst or gaseous catalyst from said reaction vessel.

336  
390. A cell according to claim 388, wherein said structure for maintaining a selected vapor pressure of said source of gaseous catalyst or said gaseous catalyst comprises a valve constructed and arranged for controlling the flow of said source of gaseous catalyst or gaseous catalyst from said reaction vessel.

339  
391. A cell according to claim 326, further comprising a valve for releasing hydrogen atoms having a binding energy of about  $E_b = 13.6/n^2$  eV, where n is a fraction whose numerator is 1 and denominator is an integer greater than 1 or a compound containing said hydrogen atoms.

346  
392. A cell according to claim 326, further comprising means for adsorbing energy released from said hydrogen atom.

341 274  
393. A cell according to claim 326, wherein said vessel comprises an internal combustion chamber.

342 341  
394. A cell according to claim 393, wherein said internal combustion chamber is an engine cylinder.

343 274  
395. A cell according to claim 326, further comprising means for controlling the power output of said cell.

ClO 344 343  
396. A cell according to claim 395, wherein said means for controlling the power output of said cell comprises means for controlling the amount of said gaseous catalyst.

345 344  
397. A cell according to claim 396, wherein said means for controlling the amount of gaseous catalyst comprises means for controlling the temperature of said vessel and said gaseous catalyst is selected to have a vapor pressure dependent upon the temperature of said reaction vessel.

346 344  
398. A cell according to claim 396, wherein said means for controlling the amount of gaseous catalyst comprises means for controlling the temperature of said catalyst reservoir and said gaseous catalyst is selected to have a vapor pressure dependent upon the temperature of said catalyst reservoir.

347 344  
399. A cell according to claim 396, wherein said means for controlling the amount of gaseous catalyst comprises means for controlling the temperature of said boat and said gaseous catalyst is selected to have a vapor pressure dependent upon the temperature of said boat.

348  
400. A cell according to claim 346, wherein said means for controlling the amount of gaseous catalyst comprises means for controlling the flow of said source of gaseous catalyst or gaseous catalyst from said catalyst reservoir into said reaction vessel.

349  
401. A cell according to claim 346, wherein said means for controlling the amount of gaseous catalyst comprises means for controlling the flow of said source of gaseous catalyst or gaseous catalyst from said catalyst reservoir from said reaction vessel.

350  
402. A cell according to claim 345, wherein said means for controlling the power output of said cell comprises means for controlling the amount of said gaseous hydrogen atoms or said source of gaseous hydrogen atoms in said vessel.

C10  
351  
403. A cell according to claim 402, wherein said means for controlling the amount of said gaseous hydrogen atoms or said source of gaseous hydrogen atoms comprises means for controlling the flow of gaseous hydrogen atoms or source of said hydrogen atoms into said vessel.

352  
404. A cell according to claim 402, wherein said means for controlling the amount of said gaseous hydrogen atoms or said source of gaseous hydrogen atoms comprises means for controlling the flow of gaseous hydrogen atoms or source of said hydrogen atoms from said vessel.

353  
405. A cell according to claim 345, wherein said means for controlling the power output of said cell comprises controlling the amount of said nonreactive gas present in said reaction vessel.

<sup>354</sup> 406. A cell according to claim <sup>353</sup> 405, wherein said means for controlling the amount of nonreactive gas comprises means for controlling the flow of said nonreactive gas into said reaction vessel.

<sup>355</sup> 407. A cell according to claim <sup>354</sup> 406, wherein said means for controlling the amount of nonreactive gas comprises means for controlling the flow of said nonreactive gas from said reaction vessel.

<sup>356</sup> 408. A cell according to claim <sup>343</sup> 395, wherein said means for controlling the power output of said cell comprises means for controlling the temperature of said source of catalyst.

<sup>C10</sup> <sup>357</sup> 409. A cell according to claim <sup>343</sup> 395, wherein said means for controlling the power output of said cell comprises means for controlling the flow of a hydrogen containing gas over at least one of a hot filament, a tungsten capillary heated by electron bombardment, or an inductively coupled plasma flow.

<sup>358</sup> 410. A cell according to claim <sup>343</sup> 395, wherein said means for controlling the power output of said cell comprises means for controlling the power dissipated in an inductively coupled plasma flow tube.

<sup>359</sup> 411. A cell according to claim <sup>343</sup> 395, wherein said means for controlling the power output of said cell comprises means for controlling the temperature of a hot filament or tungsten capillary heated by electron bombardment over which a hydrogen containing gas flows.

<sup>360</sup> 412. A cell according to claim <sup>343</sup> 395, wherein said means for controlling the power output of said cell comprises means for controlling the temperature of a hydride maintained under nonequilibrium conditions.

361 274  
413. A cell according to claim 326, further comprising means for measuring the temperature of said catalyst reservoir or said boat.

362 274  
414. A cell according to claim 326, further comprising a means for measuring the temperature of said source of said gaseous catalyst contained in said catalyst reservoir or said boat.

363 274  
415. A cell according to claim 326, further comprising means for measuring the temperature of said reaction vessel.

C10 364 274  
416. A cell according to claim 326, further comprising means for measuring the temperature of said source of said gaseous hydrogen atoms.

365 301  
417. A cell according to claim 353, further comprising means for measuring the temperature said second catalyst.

366 274  
418. A cell according to claim 326, further comprising means to measure the cell temperature.

367 274  
419. A cell according to claim 326, further comprising temperature controlling structure constructed and arranged to maintain a temperature in said reaction vessel greater than a temperature in said catalyst reservoir.

368 274  
420. A cell according to claim 326, further comprising temperature controlling structure constructed and arranged to maintain a temperature in said reaction vessel greater than a temperature in said boat.

369 374  
421. A cell according to claim 326, further comprising temperature controlling structure for maintaining a selected temperature of said reaction vessel.

370 374  
422. A cell according to claim 326, further comprising a nebulizer or atomizer.

371 374  
423. A cell according to claim 326, further comprising means to measure the pressure in said reaction vessel.

372 374  
424. A cell according to claim 326, further comprising means to measure the hydrogen pressure in said reaction vessel.

C10 373 374  
425. A cell according to claim 326, further comprising means to measure the gaseous catalyst pressure in said reaction vessel.

374 374  
426. A cell according to claim 326, wherein said vessel is capable of containing a pressure within the range of  $10^{-3}$  atmospheres to 100 atmospheres.

375  
427. A method for extracting energy from hydrogen atoms comprising the steps of:  
volatizing a source of gaseous catalyst to form a gaseous catalyst having a net enthalpy of reaction of about  $27 * (p/2)$  eV, where p is an integer greater than 1;

providing gaseous hydrogen atoms; and

reacting said gaseous catalyst with said gaseous hydrogen atoms, thereby releasing energy from said gaseous hydrogen atoms and producing hydrogen atoms having a binding energy of about  $E_b = 13.6/n^2$  eV, where n is a fraction whose numerator is 1 and a denominator is an integer greater than 1.

374 375  
428. A method according to claim 427, wherein said source of gaseous catalyst comprises an ionic compound which is resistant to hydrogen reduction.

377  
429. A method according to claim 427, wherein said source of gaseous catalyst comprises an ionic compound which is resistant to hydrogen reduction and which is adapted to sublime, boil or become volatile when heated.

378  
430. A method according to claim 427, wherein said source of gaseous catalyst comprises an ionic compound which is adapted to sublime, boil or become volatile when heated.

379  
431. A method according to claim 427, wherein said source of gaseous catalyst comprises an ionic compound which is resistant to thermal degradation.

C10  
380  
432. A method according to claim 427, wherein said source of gaseous catalyst comprises a salt of rubidium or potassium.

381  
433. A method according to claim 427, wherein said source of gaseous catalyst comprises a salt that can form a vapor comprising ions when heated.

382  
434. A method according to claim 427, wherein said source of gaseous catalyst comprises a salt of rubidium selected from the group consisting of RbF, RbCl, RbBr, RbI, Rb<sub>2</sub>S<sub>2</sub>, RbOH, Rb<sub>2</sub>SO<sub>4</sub>, Rb<sub>2</sub>CO<sub>3</sub>, and Rb<sub>3</sub>PO<sub>4</sub>.

383  
435. A method according to claim 427, wherein said source of gaseous catalyst comprises a salt of potassium selected from the group consisting of KF, KCl, KBr, KI, K<sub>2</sub>S<sub>2</sub>, KOH, K<sub>2</sub>SO<sub>4</sub>, K<sub>2</sub>CO<sub>3</sub>, K<sub>3</sub>PO<sub>4</sub>, and K<sub>2</sub>GeF<sub>4</sub>.

384  
436. A method according to claim 427, wherein said source of gaseous catalyst comprises at least one metal selected from the group consisting of Mo, Ti, and Rb.

375  
437. A method according to claim 427, wherein said source of gaseous catalyst comprises at least one salt selected from the group consisting of  $\text{MoI}_2$ ,  $\text{TiCl}_2$ ,  $\text{TiCl}_4$ ,  $\text{SnCl}_4$ ,  $\text{SiCl}_4$ ,  $\text{PrBr}_3$ ,  $\text{CaBr}_2$ ,  $\text{SrCl}_2$ ,  $\text{CrI}_2$ ,  $\text{TbI}_3$ ,  $\text{SbCl}_3$ ,  $\text{CrF}_3$ ,  $\text{CoCl}_2$ ,  $\text{BiCl}_3$ ,  $\text{NiCl}_2$ ,  $\text{PdF}_2$ ,  $\text{InCl}$ ,  $\text{LaCl}_3$ ,  $\text{DyCl}_3$ ,  $\text{LaI}_3$ ,  $\text{HoI}_3$ ,  $\text{KNO}_3$ ,  $\text{VF}_3$ ,  $\text{PbF}_2$ ,  $\text{VOCl}$ ,  $\text{PbI}_2$ ,  $\text{LuCl}_3$ ,  $\text{PbCl}_2$ ,  $\text{AsI}_3$ ,  $\text{HoI}_3$ ,  $\text{MoCl}_5$ ,  $\text{SnCl}_4$ ,  $\text{SbI}_3$ ,  $\text{CdI}_2$ ,  $\text{AgF}_2$ ,  $\text{AgF}$ ,  $\text{LaI}_3$ ,  $\text{ErI}_3$ ,  $\text{VCl}_4$ ,  $\text{BCl}_3$ ,  $\text{FeCl}_3$ ,  $\text{TiCl}_3$ ,  $\text{CoI}_2$ ,  $\text{CoF}_2$ ,  $\text{TlI}$ ,  $\text{TlF}$ ,  $\text{BiBr}_3$ ,  $\text{ZnBr}_2$ ,  $\text{AsI}_3$ ,  $\text{DyI}_3$ ,  $\text{HoCl}_3$ ,  $\text{MgCl}_2$ ,  $\text{CrCl}_3$ ,  $\text{PrCl}_3$ ,  $\text{SrCl}_2$ ,  $\text{FeCl}_2$ ,  $\text{NiCl}_2$ ,  $\text{CuCl}$ ,  $\text{SrCl}_2$ ,  $\text{MoCl}_2$ ,  $\text{YCl}_3$ ,  $\text{ZrCl}_4$ ,  $\text{CdI}_2$ ,  $\text{BaI}_2$ ,  $\text{HoI}_3$ ,  $\text{PbI}_2$ ,  $\text{PdF}_2$ ,  $\text{LiF}$ ,  $\text{EuCl}_3$ ,  $\text{MgCl}_2$ ,  $\text{ErCl}_3$ ,  $\text{MgCl}_2$ ,  $\text{ErCl}_3$ ,  $\text{MgCl}_2$ ,  $\text{BiCl}_4$ ,  $\text{AlCl}_3$ ,  $\text{CaBr}_2$ ,  $\text{SmBr}_3$ ,  $\text{VaF}_3$ ,  $\text{LaCl}_3$ ,  $\text{GdI}_3$ ,  $\text{CrI}_2$ ,  $\text{MnI}_2$ ,  $\text{YbBr}_3$ ,  $\text{FeBr}_2$ ,  $\text{NiCl}_2$ ,  $\text{AgCl}$ ,  $\text{ZnCl}_2$ ,  $\text{YbCl}_2$ ,  $\text{SeF}_4$ ,  $\text{SnCl}_4$ ,  $\text{SnF}_4$ ,  $\text{SbI}_3$ ,  $\text{BiI}_2$ ,  $\text{EuF}_3$ , and  $\text{PbCl}_2$ .

375  
438. A method according to claim 427, wherein said gaseous catalyst comprises at least one ion selected from the group consisting of  $\text{Mo}^{2+}$ ,  $\text{Ti}^{2+}$ , and  $\text{Rb}^+$ .

375  
439. A method according to claim 427, wherein said gaseous catalyst comprises at least one pair of ions selected from the group consisting of: ( $\text{Sn}^{4+}$ ,  $\text{Si}^{4+}$ ), ( $\text{Pr}^{3+}$ ,  $\text{Ca}^{2+}$ ), ( $\text{Sr}^{2+}$ ,  $\text{Cr}^{2+}$ ), ( $\text{Cr}^{3+}$ ,  $\text{Tb}^{3+}$ ), ( $\text{Sb}^{3+}$ ,  $\text{Co}^{2+}$ ), ( $\text{Bi}^{3+}$ ,  $\text{Ni}^{2+}$ ), ( $\text{Pd}^{2+}$ ,  $\text{In}^+$ ), ( $\text{La}^{3+}$ ,  $\text{Dy}^{3+}$ ), ( $\text{La}^{3+}$ ,  $\text{Ho}^{3+}$ ), ( $\text{K}^+$ ,  $\text{K}^+$ ), ( $\text{V}^{3+}$ ,  $\text{Pd}^{2+}$ ), ( $\text{Lu}^{3+}$ ,  $\text{Zn}^{2+}$ ), ( $\text{As}^{3+}$ ,  $\text{Ho}^{3+}$ ), ( $\text{Mo}^{5+}$ ,  $\text{Sn}^{4+}$ ), ( $\text{Sb}^{3+}$ ,  $\text{Cd}^{2+}$ ), ( $\text{Ag}^{2+}$ ,  $\text{Ag}^+$ ), ( $\text{La}^{3+}$ ,  $\text{Er}^{3+}$ ), ( $\text{V}^{4+}$ ,  $\text{B}^{3+}$ ), ( $\text{Fe}^{3+}$ ,  $\text{Ti}^{3+}$ ), ( $\text{Co}^{2+}$ ,  $\text{Ti}^+$ ), ( $\text{Bi}^{3+}$ ,  $\text{Zn}^{2+}$ ), ( $\text{As}^{3+}$ ,  $\text{Dy}^{3+}$ ), ( $\text{Ho}^{3+}$ ,  $\text{Mg}^{2+}$ ), ( $\text{K}^+$ ,  $\text{Rb}^+$ ), ( $\text{Cr}^{3+}$ ,  $\text{Pr}^{3+}$ ), ( $\text{Sr}^{2+}$ ,  $\text{Fe}^{2+}$ ), ( $\text{Ni}^{2+}$ ,  $\text{Cu}^+$ ), ( $\text{Sr}^{2+}$ ,  $\text{Mo}^{2+}$ ), ( $\text{Y}^{3+}$ ,  $\text{Zr}^{4+}$ ), ( $\text{Cd}^{2+}$ ,  $\text{Ba}^{2+}$ ), ( $\text{Ho}^{3+}$ ,  $\text{Pb}^{2+}$ ), ( $\text{Pb}^{2+}$ ,  $\text{Li}^+$ ), ( $\text{Eu}^{3+}$ ,  $\text{Mg}^{2+}$ ), ( $\text{Er}^{3+}$ ,  $\text{Mg}^{2+}$ ), ( $\text{Bi}^{4+}$ ,  $\text{Al}^{3+}$ ), ( $\text{Ca}^{2+}$ ,  $\text{Sm}^{3+}$ ), ( $\text{V}^{3+}$ ,  $\text{La}^{3+}$ ), ( $\text{Gd}^{3+}$ ,  $\text{Cr}^{2+}$ ), ( $\text{Mn}^{2+}$ ,  $\text{Ti}^+$ ), ( $\text{Yb}^{3+}$ ,  $\text{Fe}^{2+}$ ), ( $\text{Ni}^{2+}$ ,  $\text{Ag}^+$ ), ( $\text{Zn}^{2+}$ ,  $\text{Yb}^{2+}$ ), ( $\text{Se}^{4+}$ ,  $\text{Sn}^{4+}$ ), ( $\text{Sb}^{3+}$ ,  $\text{Bi}^{2+}$ ), and ( $\text{Eu}^{3+}$ ,  $\text{Pb}^{2+}$ ).

375  
440. A method according to claim 427, wherein said source of gaseous catalyst comprises a salt of one or more cations and at least one anion selected from the group consisting of halides, sulfates, phosphates, carbonates, hydroxide and sulfides.



389  
441. A method according to claim 375, wherein said gaseous catalyst comprises hydrogen atoms having a binding energy of about  $E_b = 13.6/n^2$  eV, where n is a fraction whose numerator is 1 and denominator is an integer greater than 1.

390  
442. A method according to claim 375, wherein said catalyst is selected to have a resonant adsorption with the energy released from said gaseous hydrogen atoms undergoing a transition to a lower energy state.

391  
443. A method according to claim 375, wherein said gaseous catalyst comprises potassium and has a net enthalpy of reaction of 27.28 eV.

392  
444. A method according to claim 375, wherein said gaseous catalyst has a net enthalpy of reaction of about 27.2 eV.

393  
445. A method according to claim 375, further comprising the step of combining a source of gaseous catalyst with a source of gaseous hydrogen atoms comprising at least one of a hydrocarbon or water, and providing combustion which volatilizes said source of gaseous catalyst to form said gaseous catalyst and provide said gaseous hydrogen atoms.

394  
446. A method according to claim 375, further comprising the step of forming said source of gaseous catalyst or said gaseous catalyst in situ.

395  
447. A method according to claim 344, wherein said step of forming said source of gaseous catalyst or said gaseous catalyst in situ comprises the ionization of a reactant.

396  
448. A method according to claim 345, wherein said step of ionization comprises thermal ionization of said reactant.

<sup>397</sup>  
449. A method according to claim <sup>395</sup>447, wherein said step of ionization comprises chemical ionization of said reactant.

<sup>398</sup>  
450. A method according to claim <sup>397</sup>449, wherein said step of chemical ionization comprises oxidation or reduction of said reactant.

<sup>399</sup>  
451. A method according to claim <sup>375</sup>427, wherein said step of volatizing said source of, catalyst to form said gaseous catalyst utilizes energy from at least one of heat, electron-beam energy, photon energy, acoustic energy, electric field, or magnetic field.

<sup>400</sup>  
452. A method according to claim <sup>375</sup>427, wherein said step of volatizing said source of catalyst comprises the step of heating a filament coated with said source of said gaseous catalyst.

<sup>401</sup>  
453. A method according to claim <sup>375</sup>427, wherein said step of volatizing said source of gaseous catalyst to form said gaseous catalyst comprises the steps of volatizing said material to form gaseous atoms and ionizing said gaseous atoms to form ions.

<sup>402</sup>  
454. A method according to claim <sup>375</sup>427, further comprising adding a source of catalyst to said reaction vessel and heating said source of catalyst to form said gaseous catalyst.

<sup>403</sup>  
455. A method according to claim <sup>375</sup>427, wherein said source of catalyst is provided in a catalyst reservoir comprising a container separate from said reaction vessel and said container communicates with said reaction vessel.

456. A method according to claim 427, wherein said source of catalyst is provided in a boat contained within said reaction vessel.

457. A method according to claim 427, wherein said step of providing hydrogen atoms comprises the steps of disassociating a hydrogen containing compound into hydrogen atoms.

458. A method according to claim 427, wherein said step of providing hydrogen atoms comprises the steps of passing a hydrogen containing gas over a hot filament.

459. A method according to claim 427, wherein said step of providing hydrogen atoms comprises the steps of passing a hydrogen containing gas over a hot grid.

460. A method according to claim 427, wherein said step of providing hydrogen atoms comprises the steps of passing a hydrogen containing gas through a tungsten capillary heated by electron bombardment.

461. A method according to claim 427, wherein said step of providing hydrogen atoms comprises the steps of maintaining a hydride under nonequilibrium conditions.

462. A method according to claim 427, wherein said step of providing hydrogen atoms comprises the steps of passing a hydrogen containing gas through an inductively coupled plasma flow tube.

463. A method according to claim 427, wherein said step of providing hydrogen atoms comprises the steps of contacting a hydrogen containing gas with a second catalyst for disassociating said hydrogen containing gas into free hydrogen atoms.

412  
464. A method according to claim 463, wherein said second catalyst comprises at least one element selected from the group consisting of transition elements, inner transition elements, precious metals, refractory metals, lanthanides, actinides and activated charcoal.

413  
465. A method according to claim 463, wherein said second catalyst is selected from the group consisting of an element, compound, alloy or mixture of transition elements, inner transition elements, iron, platinum, palladium, zirconium, vanadium, nickel, titanium, Sc, Cr, Mn, Co, Cu, Zn, Y, Nb, Mo, Tc, Ru, Rh, Ag, Cd, La, Hf, Ta, W, Re, Os, Ir, Au, Hg, Ce, Pr, Nd, Pm, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Vb, Lu, Th, Pa, U, activated charcoal, and intercalated Cs carbon.

414  
466. A method according to claim 463, further comprising the step of utilizing a hot filament or hot grid to disassociate a hydrogen containing gas into gaseous hydrogen atoms and to heat said second catalyst.

415  
467. A method according to claim 463, further comprising the step of controlling the power output of said cell.

416  
468. A method according to claim 467, wherein said step of controlling the power output of said cell comprises controlling the temperature of said second catalyst.

417  
469. A method according to claim 468, wherein said step of controlling the temperature of said second catalyst comprises utilizing a heated filament or grid.

418  
470. A method according to claim 467, wherein said source of gaseous hydrogen atoms is selected from the group consisting of hydrogen gas, water, hydrides, metal-hydrogen solutions, and hydrocarbons.

419 375  
471. A method according to claim 427, wherein said step of providing gaseous hydrogen atoms comprises pyrolyzing hydrocarbons or water.

420 375  
472. A method according to claim 427, further comprising the step of reforming hydrocarbons to at least one of gaseous molecular and gaseous atomic hydrogen.

421 375  
473. A method according to claim 427, further comprising the step of disassociating hydrogen containing molecules using UV light to form said gaseous hydrogen atoms.

C10 422 375  
474. A method according to claim 427, further comprising the step of controlling the amount of gaseous hydrogen provided in said reaction vessel.

423 375  
475. A method according to claim 427, further comprising the step of controlling the flow of a source of gaseous hydrogen atoms or said gaseous hydrogen atoms from a chamber to said reaction vessel.

424 375  
476. A method according to claim 427, further comprising the step of utilizing a valve for controlling the flow of gaseous hydrogen or source of gaseous hydrogen from said reaction vessel.

425 375  
477. A method according to claim 427, further comprising the step of controlling the flow of gaseous hydrogen or source of gaseous hydrogen from said reaction vessel.

426 375  
478. A method according to claim 427, further comprising the step of utilizing a vacuum pump for controlling the flow of gaseous hydrogen or source of gaseous hydrogen from said reaction vessel.

427  
429. A method according to claim 427, further comprising the step of utilizing a valve for controlling the flow of gaseous hydrogen or source of gaseous hydrogen from a chamber into said reaction vessel.

428  
430. A method according to claim 427, further comprising controlling the partial pressure of said gaseous hydrogen atoms.

429  
431. A method according to claim 427, wherein a partial pressure of said gaseous hydrogen atoms or source of gaseous hydrogen atoms in said reaction vessel is maintained within the range of  $10^{-3}$  atmospheres to 100 atmospheres.

C10  
430  
432. A method according to claim 427, further comprising controlling the amount of gaseous catalyst or source of gaseous catalyst introduced into said reaction vessel.

431  
433. A method according to claim 427, further comprising controlling the flow of gaseous catalyst or source of gaseous catalyst from a catalyst reservoir containing gaseous catalyst or a source of gaseous catalyst to said reaction vessel.

432  
434. A method according to claim 427, further comprising controlling the flow of gaseous catalyst or source of gaseous catalyst from a boat containing gaseous catalyst or a source of gaseous catalyst.

433  
435. A method according to claim 427, further comprising the step of controlling the flow of said gaseous catalyst or said source of gaseous catalyst from said reaction vessel.

434  
436. A method according to claim 427, further comprising the step of controlling the vapor pressure of said gaseous catalyst or source of gaseous catalyst in said reaction vessel.

<sup>435</sup>  
487. A method according to claim <sup>375</sup>427, wherein a vapor pressure of said gaseous catalyst or said source of gaseous catalyst is maintained at about 50 to 210 millitorr.

<sup>436</sup>  
488. A method according to claim <sup>375</sup>427, further comprising using a vacuum pump to control the flow of said catalyst or said source of gaseous catalyst from said reaction vessel.

<sup>437</sup>  
489. A method according to claim <sup>375</sup>427, further comprising using a valve to control the flow of said source of gaseous catalyst or said catalyst from a catalyst reservoir into said reaction vessel.

<sup>438</sup>  
490. A method according to claim <sup>375</sup>427, further comprising using a valve to control the flow of said source of gaseous catalyst or said catalyst from said reaction vessel.

<sup>439</sup>  
491. A method according to claim <sup>375</sup>427, further comprising the step of supplying a nonreactive gas to said reaction vessel.

<sup>440</sup>  
492. A method according to claim <sup>375</sup>427, further comprising the step of controlling the vapor pressure of said nonreactive gas in said reaction vessel.

<sup>441</sup>  
493. A method according to claim <sup>440</sup>492, further comprising the step of controlling the flow of said nonreactive gas supplied to said reaction vessel.

<sup>442</sup>  
494. A method according to claim <sup>440</sup>492, further comprising the step of controlling the amount of said nonreactive gas released from said reaction vessel.

<sup>443</sup>  
495. A method according to claim <sup>440</sup>492, further comprising utilizing a vacuum pump for controlling the flow of said nonreactive gas from said reaction vessel.

444  
486. A method according to claim 482, further comprising the step of utilizing a valve for controlling the flow of said nonreactive gas from said reaction vessel.

445  
487. A method according to claim 482, further comprising the step of utilizing a valve for controlling the flow of said nonreactive gas into said reaction vessel.

446  
488. A method according to claim 427, further comprising the step of controlling the vapor pressure of said gaseous catalyst in said reaction vessel.

447  
489. A method according to claim 488, wherein said step of controlling the vapor pressure of said gaseous catalyst comprises controlling the temperature in a catalyst reservoir containing a source of gaseous catalyst or said gaseous catalyst and being in communication with said reaction vessel, and controlling the flow of gaseous catalyst from said catalyst reservoir.

448  
500. A method according to claim 488, wherein said step of controlling the vapor pressure of said gaseous catalyst comprises controlling the temperature in a boat containing a source of gaseous catalyst or said gaseous catalyst and being contained in said reaction vessel, and controlling the flow of gaseous catalyst from said boat.

449  
501. A method according to claim 427, further comprising the step of controlling the temperature in a catalyst reservoir containing a source of gaseous catalyst or said gaseous catalyst and being in communication with said reaction vessel.

450  
502. A method according to claim 427, further comprising the step of controlling the temperature in a boat containing a source of gaseous catalyst or said gaseous catalyst and being contained in said reaction vessel.



451  
503. A method according to claim 427, wherein the reaction to provide a net enthalpy of about  $27 (p/2)$  eV, where  $p$  is a positive integer greater than 1, comprises an electrochemical, chemical, photochemical, thermal, free radical, sonic, nuclear, inelastic photon, or particle scattering reaction, or mixtures thereof.

452  
504. A method according to claim 427, wherein a pressure in said reaction vessel is maintained within the range of  $10^{-3}$  atmospheres to 100 atmospheres.

C10  
453  
505. A method according to claim 427, wherein said reaction occurring at a pressure less than atmospheric pressure.

454  
506. A method according to claim 427, further comprising the step of releasing hydrogen atoms from said reaction vessel having a binding energy of about  $E_b = 13.6/n^2$  eV, where  $n$  is a fraction whose numerator is 1 and denominator is an integer greater than 1 or a compound containing said hydrogen atoms.

455  
507. A method according to claim 427, further comprising the step of adsorbing said released energy.

456  
508. A method according to claim 427, further comprising the step of converting energy released from said hydrogen atom into electrical energy.

457  
509. A method according to claim 427, wherein said reaction step is conducted in an internal combustion chamber.

458  
510. A method according to claim 509, wherein said internal combustion chamber is an engine cylinder.

<sup>459</sup>511. A method according to claim <sup>375</sup>427, further comprising the step of controlling the power output of said cell.

<sup>460</sup>512. A method according to claim <sup>459</sup>511, wherein said step of controlling the power output of said cell comprises controlling the amount of said gaseous catalyst present in said reaction vessel.

<sup>461</sup>513. A method according to claim <sup>460</sup>512, wherein said step of controlling the amount of gaseous catalyst comprises controlling the temperature of said reaction vessel and selecting said gaseous catalyst to have a vapor pressure dependent upon the temperature of said reaction vessel.

<sup>462</sup>514. A method according to claim <sup>460</sup>512, wherein said step of controlling the amount of gaseous catalyst comprises controlling the temperature of a catalyst reservoir containing a source of gaseous catalyst or said gaseous and being in communication with said reaction vessel, and selecting said gaseous catalyst to have a vapor pressure dependent upon the temperature of said catalyst reservoir.

<sup>463</sup>515. A method according to claim <sup>460</sup>512, wherein said step of controlling the amount of gaseous catalyst comprises controlling the flow of said source of gaseous catalyst or gaseous catalyst from said catalyst reservoir into said reaction vessel.

<sup>464</sup>516. A method according to claim <sup>460</sup>512, wherein said step of controlling the amount of gaseous catalyst comprises controlling the flow of said source of gaseous catalyst or gaseous catalyst from said reaction vessel.

<sup>465</sup>517. A method according to claim <sup>460</sup>512, wherein said step of controlling the amount of gaseous catalyst comprises controlling the temperature of a boat containing a source of gaseous catalyst or said gaseous and being contained in said reaction

vessel, and selecting said gaseous catalyst to have a vapor pressure dependent upon the temperature of said boat.

466  
518. A method according to claim 511, wherein said step of controlling the power output of said cell comprises controlling the amount of said gaseous hydrogen atoms or source of gaseous hydrogen atoms present in said reaction vessel.

467  
519. A method according to claim 518, wherein said step of controlling the amount of said gaseous hydrogen atoms or source of gaseous hydrogen atoms comprises controlling the flow of gaseous hydrogen atoms or source of gaseous hydrogen atoms into said reaction vessel.

468  
520. A method according to claim 518, wherein said step of controlling the amount of said source of gaseous hydrogen atoms or gaseous hydrogen atoms comprises controlling the flow of said source of gaseous hydrogen atoms or gaseous hydrogen atoms from said reaction vessel.

469  
521. A method according to claim 518, wherein said step of controlling the amount of said source of gaseous hydrogen atoms or gaseous hydrogen atoms comprises controlling the temperature of a second catalyst for dissociating a hydrogen containing compound into gaseous hydrogen atoms.

470  
522. A method according to claim 521, wherein said step of controlling the temperature of a second catalyst for dissociating a hydrogen containing compound into gaseous hydrogen atoms comprises controlling the power dissipated in a second catalyst heater.

471  
523. A method according to claim 511, wherein said step of controlling the power output of said cell comprises controlling the amount of nonreactive gas in said reaction vessel.

472  
524. A method according to claim 523, wherein said step of controlling the amount of nonreactive gas in said reaction vessel comprises controlling the flow of nonreactive gas into said reaction vessel.

473  
525. A method according to claim 524, wherein said step of controlling the amount of nonreactive gas in said reaction vessel comprises controlling the flow of nonreactive gas from said reaction vessel.

CO 474  
526. A method according to claim 511, wherein said step of controlling the power output of said cell comprises controlling the temperature of a source of gaseous catalyst.

475  
527. A method according to claim 511, wherein said step of controlling the power output of said cell comprises controlling the flow of a hydrogen containing gas over at least one of a hot filament, a tungsten capillary heated by electron bombardment, or an inductively coupled plasma flow.

476  
528. A method according to claim 511, wherein said step of controlling the power output of said cell comprises controlling the power dissipated in an inductively coupled plasma flow tube, hot filament or grid, or tungsten capillary heated by electron bombardment.

477  
529. A method according to claim 511, wherein said step of controlling the power output of said cell comprises controlling the temperature of a hot filament or tungsten capillary heated by electron bombardment over which a hydrogen containing gas flows.

<sup>478</sup> 530. A method according to claim <sup>459</sup> 511, wherein said step of controlling the power output of said cell comprises controlling the temperature of a hydride maintained under nonequilibrium conditions.

<sup>479</sup> 531. A method according to claim <sup>375</sup> 427, wherein a temperature in said reaction vessel is maintained at a higher temperature than in a catalyst reservoir in communication with said reaction vessel or a boat contained within said reaction vessel.

<sup>480</sup> 532. A method according to claim <sup>375</sup> 427, further comprising the step of measuring the temperature of a catalyst reservoir in communication with said reaction vessel or a boat contained in said reaction vessel.

<sup>481</sup> 533. A method according to claim <sup>375</sup> 427, further comprising the step of measuring the temperature of a source of said gaseous catalyst contained in a catalyst reservoir in communication with said reaction vessel or a boat contained within said reservoir.

<sup>482</sup> 534. A method according to claim <sup>375</sup> 427, further comprising the step of measuring the temperature of a chamber containing a source of said hydrogen atoms in communication with said reaction vessel.

<sup>483</sup> 535. A method according to claim <sup>375</sup> 427, further comprising the step of measuring the temperature of a source of said gaseous hydrogen atoms.

<sup>484</sup> 536. A method according to claim <sup>411</sup> 463, further comprising the step of measuring the temperature of said second catalyst.

<sup>485</sup> 537. A method according to claim <sup>375</sup> 427, further comprising the step of controlling the temperature of said reaction vessel.

486 375  
538. A method according to claim 427, further comprising utilizing a nebulizer or atomizer to form said gaseous catalyst.

487 375  
539. A method according to claim 427, further comprising the step of measuring the pressure in said reaction vessel.

488 375  
540. A method according to claim 427, further comprising the step of controlling the pressure in said reaction vessel.

489 375  
541. A method according to claim 427, further comprising the step of measuring the hydrogen pressure in said reaction vessel.

490 375  
542. A method according to claim 427, further comprising the step of measuring the gaseous catalyst pressure in said reaction vessel.

491 375  
543. A method according to claim 427, further comprising the step of converting energy released from said gaseous hydrogen atoms into electrical energy.

492 375  
544. A method according to claim 427, further comprising controlling the pressure of said gaseous catalyst by controlling the amount of said source of catalyst being added to said reaction vessel.

493  
545. A cell comprising:  
a reaction vessel capable of containing a vacuum or pressures greater than atmospheric;  
a source of hydrogen atoms; and

a source of a gaseous catalyst or a gaseous catalyst capable of accepting energy from atomic hydrogen thereby catalyzing a transition of the electron of atomic hydrogen to a state lower than that of uncatalyzed hydrogen.

494

546.

A cell comprising:

a reaction vessel capable of containing a vacuum or pressures greater than atmospheric;

a source of hydrogen atoms; and

C10  
a source of a gaseous catalyst or a gaseous catalyst capable of accepting energy from atomic hydrogen thereby catalyzing a transition of the electron of atomic hydrogen to a state lower than that of uncatalyzed hydrogen and releasing energy from said hydrogen atom, wherein said gaseous catalyst comprises hydrogen atoms having a binding energy of about  $E_b = 13.6/n^2$  eV, where  $n$  is a fraction whose numerator is 1 and denominator is an integer greater than 1.

495

547.

A cell comprising:

a reaction vessel capable of containing a vacuum or pressures greater than atmospheric;

a source of hydrogen atoms; and

a source of a gaseous catalyst or a gaseous catalyst capable of accepting energy from atomic hydrogen thereby catalyzing a transition of the electron of atomic hydrogen to a state lower than that of uncatalyzed hydrogen and releasing energy from said hydrogen atom, wherein said source of gaseous catalyst comprises at least one salt selected from the group consisting of RbF, RbCl, RbBr, RbI, Rb<sub>2</sub>S<sub>2</sub>, RbOH, Rb<sub>2</sub>SO<sub>4</sub>, Rb<sub>2</sub>CO<sub>3</sub>, Rb<sub>3</sub>PO<sub>4</sub>, KF, KCl, KBr, KI, K<sub>2</sub>S<sub>2</sub>, KOH, K<sub>2</sub>SO<sub>4</sub>, K<sub>2</sub>CO<sub>3</sub>, K<sub>3</sub>PO<sub>4</sub>, and K<sub>2</sub>GeF<sub>4</sub>.

496

548.

A cell comprising:

a reaction vessel capable of containing a vacuum or pressures greater than atmospheric;

a source of hydrogen atoms; and

a source of a gaseous catalyst or a gaseous catalyst capable of accepting energy from atomic hydrogen thereby catalyzing a transition of the electron of atomic hydrogen to a state lower than that of uncatalyzed hydrogen and releasing energy from said hydrogen atom, wherein said gaseous catalyst comprises at least one ion selected from the group consisting of  $\text{Mo}^{2+}$ ,  $\text{Ti}^{2+}$ , and  $\text{Rb}^+$ .

497  
549.

A cell comprising:

a reaction vessel capable of containing a vacuum or pressures greater than atmospheric;

a source of hydrogen atoms; and

a source of a gaseous catalyst or a gaseous catalyst capable of accepting energy from atomic hydrogen thereby catalyzing a transition of the electron of atomic hydrogen to a state lower than that of uncatalyzed hydrogen and releasing energy from said hydrogen atom, wherein said source of gaseous catalyst comprises at least one metal selected from the group consisting of Mo, Ti, and Rb.

498  
550.

A cell comprising:

a reaction vessel capable of containing a vacuum or pressures greater than atmospheric;

a source of hydrogen atoms; and

a source of a gaseous catalyst or a gaseous catalyst capable of accepting energy from atomic hydrogen thereby catalyzing a transition of the electron of atomic hydrogen to a state lower than that of uncatalyzed hydrogen and releasing energy from said hydrogen atom, wherein said source of gaseous catalyst comprises at least one salt selected from the group consisting of  $\text{MoI}_2$ ,  $\text{TiCl}_2$ ,  $\text{TiCl}_4$ ,  $\text{SnCl}_4$ ,  $\text{SiCl}_4$ ,  $\text{PrBr}_3$ ,  $\text{CaBr}_2$ ,  $\text{SrCl}_2$ ,  $\text{CrI}_2$ ,  $\text{TbI}_3$ ,  $\text{SbCl}_3$ ,  $\text{CrF}_3$ ,  $\text{CoCl}_2$ ,  $\text{BiCl}_3$ ,  $\text{NiCl}_2$ ,  $\text{PdF}_2$ ,



InCl, LaCl<sub>3</sub>, DyCl<sub>3</sub>, LaI<sub>3</sub>, HoI<sub>3</sub>, KNO<sub>3</sub>, VF<sub>3</sub>, PbF<sub>2</sub>, VOCl, PbI<sub>2</sub>, LuCl<sub>3</sub>, PbCl<sub>2</sub>, AsI<sub>3</sub>, HoI<sub>3</sub>, MoCl<sub>5</sub>, SnCl<sub>4</sub>, SbI<sub>3</sub>, CdI<sub>2</sub>, AgF<sub>2</sub>, AgF, LaI<sub>3</sub>, ErI<sub>3</sub>, VCl<sub>4</sub>, BCl<sub>3</sub>, FeCl<sub>3</sub>, TiCl<sub>3</sub>, CoI<sub>2</sub>, CoF<sub>2</sub>, TlI, TlF, BiBr<sub>3</sub>, ZnBr<sub>2</sub>, AsI<sub>3</sub>, DyI<sub>3</sub>, HoCl<sub>3</sub>, MgCl<sub>2</sub>, CrCl<sub>3</sub>, PrCl<sub>3</sub>, SrCl<sub>2</sub>, FeCl<sub>2</sub>, NiCl<sub>2</sub>, CuCl, SrCl<sub>2</sub>, MoCl<sub>2</sub>, YCl<sub>3</sub>, ZrCl<sub>4</sub>, CdI<sub>2</sub>, BaI<sub>2</sub>, HoI<sub>3</sub>, PbI<sub>2</sub>, PdF<sub>2</sub>, LiF, EuCl<sub>3</sub>, MgCl<sub>2</sub>, ErCl<sub>3</sub>, MgCl<sub>2</sub>, ErCl<sub>3</sub>, MgCl<sub>2</sub>, BiCl<sub>4</sub>, AlCl<sub>3</sub>, CaBr<sub>2</sub>, SmBr<sub>3</sub>, VaF<sub>3</sub>, LaCl<sub>3</sub>, GdI<sub>3</sub>, CrI<sub>2</sub>, MnI<sub>2</sub>, YbBr<sub>3</sub>, FeBr<sub>2</sub>, NiCl<sub>2</sub>, AgCl, ZnCl<sub>2</sub>, YbCl<sub>2</sub>, SeF<sub>4</sub>, SnCl<sub>4</sub>, SnF<sub>4</sub>, SbI<sub>3</sub>, BiI<sub>2</sub>, EuF<sub>3</sub>, and PbCl<sub>2</sub>.

499  
51. A cell comprising:

a reaction vessel capable of containing a vacuum or pressures greater than atmospheric;

a source of hydrogen atoms; and

a source of a gaseous catalyst or a gaseous catalyst capable of accepting energy from atomic hydrogen thereby catalyzing a transition of the electron of atomic hydrogen to a state lower than that of uncatalyzed hydrogen and releasing energy from said hydrogen atom, wherein said gaseous catalyst comprises at least one pair of ions selected from the group consisting of: (Sn<sup>4+</sup>, Si<sup>4+</sup>), (Pr<sup>3+</sup>, Ca<sup>2+</sup>), (Sr<sup>2+</sup>, Cr<sup>2+</sup>), (Cr<sup>3+</sup>, Tb<sup>3+</sup>), (Sb<sup>3+</sup>, Co<sup>2+</sup>), (Bi<sup>3+</sup>, Ni<sup>2+</sup>), (Pd<sup>2+</sup>, In<sup>+</sup>), (La<sup>3+</sup>, Dy<sup>3+</sup>), (La<sup>3+</sup>, Ho<sup>3+</sup>), (K<sup>+</sup>, K<sup>+</sup>), (V<sup>3+</sup>, Pd<sup>2+</sup>), (Lu<sup>3+</sup>, Zn<sup>2+</sup>), (As<sup>3+</sup>, Ho<sup>3+</sup>), (Mo<sup>5+</sup>, Sn<sup>4+</sup>), (Sb<sup>3+</sup>, Cd<sup>2+</sup>), (Ag<sup>2+</sup>, Ag<sup>+</sup>), (La<sup>3+</sup>, Er<sup>3+</sup>), (V<sup>4+</sup>, B<sup>3+</sup>), (Fe<sup>3+</sup>, Ti<sup>3+</sup>), (Co<sup>2+</sup>, Ti<sup>+</sup>), (Bi<sup>3+</sup>, Zn<sup>2+</sup>), (As<sup>3+</sup>, Dy<sup>3+</sup>), (Ho<sup>3+</sup>, Mg<sup>2+</sup>), (K<sup>+</sup>, Rb<sup>+</sup>), (Cr<sup>3+</sup>, Pr<sup>3+</sup>), (Sr<sup>2+</sup>, Fe<sup>2+</sup>), (Ni<sup>2+</sup>, Cu<sup>+</sup>), (Sr<sup>2+</sup>, Mo<sup>2+</sup>), (Y<sup>3+</sup>, Zr<sup>4+</sup>), (Cd<sup>2+</sup>, Ba<sup>2+</sup>), (Ho<sup>3+</sup>, Pb<sup>2+</sup>), (Pb<sup>2+</sup>, Li<sup>+</sup>), (Eu<sup>3+</sup>, Mg<sup>2+</sup>), (Er<sup>3+</sup>, Mg<sup>2+</sup>), (Bi<sup>4+</sup>, Al<sup>3+</sup>), (Ca<sup>2+</sup>, Sm<sup>3+</sup>), (V<sup>3+</sup>, La<sup>3+</sup>), (Gd<sup>3+</sup>, Cr<sup>2+</sup>), (Mn<sup>2+</sup>, Ti<sup>+</sup>), (Yb<sup>3+</sup>, Fe<sup>2+</sup>), (Ni<sup>2+</sup>, Ag<sup>+</sup>), (Zn<sup>2+</sup>, Yb<sup>2+</sup>), (Se<sup>4+</sup>, Sn<sup>4+</sup>), (Sb<sup>3+</sup>, Bi<sup>2+</sup>), and (Eu<sup>3+</sup>, Pb<sup>2+</sup>).